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ORIGINAL ARTICLES.

I.—Æolian Deposits on the Coast at Étel, Morbihan. Part II.

By the Rev. R. Ashington Bullen, B.A.Lond., F.L.S., F.G.S., etc.

(PLATES IX AND X.)

§ 1. Description of microscopic sections of pebbles forming the Raised Beach at Étel.

§ 2. Description of the photographs illustrating facts contained in Part I of this paper.

THIS brief article is necessitated by the impossibility of procuring photographs and rock sections in time for incorporation in my former paper in the January number of the Geological Magazine, pp. 6–15.

§ 1. The rocks (i) of the Raised Beach at Étel and (ii) of the local granulite (in the French sense of the word) have been submitted to Mr. Russell F. Gwinnell, B.Sc., of the Royal College of Science, South Kensington, and after having had specially thin sections of them prepared, he reports as follows:—

Petrographic Description of Rocks from Étel, Brittany, collected by the Rev. R. Ashington Bullen.

(Plate X, Figs. 1–5.)

These rocks are all quartzites, varying slightly as to accessory constituents, and differing from one another more as to the degree in which the superinduced or metamorphic structures are exhibited. Textural differences also slightly accentuate the variation in appearance. One is reminded of the schistose grits or quartz-schists of the Dalradian Series of the South-West Highlands of Scotland, but still more forcibly of the Cambrian quartzites of the North-West Highland complex.

Pl. X, Fig. 1, is a very fine-grained rock, with a foliated structure which, though quite well marked under polarized light, is not apparent in ordinary light. It consists mainly of minute elongated granules of quartz, forming a fine mosaic of interlocking individuals. Undulatory extinction indicates mechanical strain. The rock is intersected by numerous veins running in many different directions, and consisting of comparatively coarse crystals of quartz, full of minute inclusions and secondary in origin. Many minute rounded grains of an opaque black material are distributed throughout the rock, and, by their local abundance, render it opaque in patches. This material suggests carbonaceous matter, but it is impossible to definitely identify it under the microscope. Occasional small brownish patches of indefinite characters suggest a coloured mica or micaceous hæmatite.

Pl. X, Fig. 2, is much coarser in texture, the quartz-grains, which are extremely irregular in shape, varying very considerably in dimensions. The interlocking of the grains is striking, but foliation is not evident. Strain polarization effects are well shown, especially in the larger individuals. Small streaks and patches of brown material occur, as in Fig. 1, and a slight film of it envelops each quartz-grain. Minute inclusions, probably of liquid or gaseous matter, are abundant in the quartz, and in places occur in long series, continuous through adjacent crystals.

In Pl. X, Fig. 3, the foliation is again seen to be distinct, and the quartz-grains are fairly uniform in size: a sort of groundwork of smaller grains has, scattered through it, elongated crystals of much greater dimensions, but agreeing approximately in size with one another. Many of the crystals, both of the smaller and the larger size, are fairly regular in contour, being three or four times as long as they are wide. Undulatory extinction is common, inclusions are quite rare, while the brown-red indefinite staining material is very abundant, and has the characters of hæmatite in places.

Pl. X, Fig. 4, is coarser in texture than any of the others. All the grains are large and most of them elongated, so that the foliation is well seen. Inclusions are not abundant, but in places occur in series, especially along lines of apparently incipient fracture. The brown-red colouring matter is fairly abundant, and a very little mica is suggested here and there. Undulatory extinction is again noticeable.

Pl. X, Fig. 5. In structure this rock is holocrystalline, hypidiomorphic, without porphyritic constituents; its texture is of medium coarseness. The specimen is somewhat decomposed, as is shown by the partial kaolinization of felspars, while there is a decided tendency for the individual crystals to separate from one another to produce an angular sand. In mass the rock is very pale in colour, and white mica, felspar, and quartz are easily recognizable; the few dark streaky patches seen by the naked eye are found by microscopic examination to be biotite. Under the microscope *felspars* are seen to be most abundant, the other essential constituents being *quartz*, *muscovite*, and *biotite*. The two micas are, in several instances, in parallel growth, while the contours of the various crystals show that the micas have usually preceded the felspars, and the quartz has succeeded them in order of crystallization. The felspars are invariably kaolinized, but not to a great extent. In some cases an outer zone of nearly fresh felspar surrounds a kaolinized kernel. The simple twinning of *orthoclase* is seen in numerous crystals, while others are striated. Some of these *plagioclases* show simple twinning together with twinning on the albite law, while a very few exhibit the cross-hatching due to albite with pericline twinning: these latter may be considered as *microcline*. A number of observations of extinctions in plagioclases exhibiting albite twinning gave low readings (5°–12°); thus these are *oligoclase-andesine*. The quartz is clear, with a few minute inclusions, and is mostly quite allotriomorphic. The micas are abundant, well-shaped, and usually associated in parallel growth. The muscovite is quite clear and colourless, while the biotite is of a greenish-brown colour with moderately strong pleochroism: its

birefringence shows that the green tint is not due to chloritization: inclusions with slight pleochroic halos are found. Accessory and secondary constituents (other than kaolin) are uncommon, a little granular epidote being alone noteworthy: this is associated with, and presumably derived from, decomposed felspars. This rock is a 'granite-proper' or 'two-mica granite', the 'muscovite-granite' of some authors, a 'granulite' in the French sense.

§ 2. The granulite, or muscovite-biotite granite, outcrop can be seen in Fig. 1 (Plate IX). The point thus formed is the Cap de Garde at the mouth of the Rivière d'Étel, looking across westward from the left bank, at about half-flood tide. I find that the tower (La Tourelle) does not stand actually on the rock called Le Chaudronnier; the latter is seen surrounded by water a little behind and westward, and is indicated by the white arrow pointing from above it. Consequently my former remarks must be modified to this extent, other statements of fact, however, remaining unaltered.

It was in the 'baylet' just westward of the granulite that the masses of rolled peat occurred.[1] As the prevailing winds are from the south-westward, and as strong currents seem to set from westward, the source of the submerged peat beds may possibly be to the westward too. The prevailing current is said to originate in the region of westerly winds in the Atlantic, and to flow along the north coast of Spain and up the west coast of France to the north-westward, but it is much influenced by the prevailing wind and the tidal currents.

The only submerged peat beds that have been described in Brittany lie on the north coast at Plougasnel-Primel, near Morlaix (Finistère). The deposit measures roughly 7 ft. 6 in. in thickness, and contains four well-defined vegetable layers, the upper containing stools of trees (beech, holly, and hazel). There are two well-marked peat beds, the upper being ·40 metre and the lower ·55 metre in thickness (see L. Cayeux, Bibliography, *al fin.*). M. Jos. Bourlot also mentions a submerged forest (elm) at Pointe du Raz, and suggests others round the Bay of Douarnénez (see J. Bourlot, Bibliography, *al fin.*).

The lines of white quartz pebbles on the left bank are most probably derived from old Raised Beaches of Pleistocene age (now obliterated, except fragmentarily), just as the pebbles of the Chesil Beach, in Dorset, have been derived from beaches of the same age in England.[2]

Fig. 2 (Plate IX) shows the cliff (*falaise*) on the left bank, marked 7· · · · 7, in the plan. The place from which the 'granulite' was procured for the microscope is marked with a white ×. The capping of the cliffs is of blown-sand, with grains of quartz and brown and white mica, and contains much finely broken debris of *Littium reticulatum*, as well as many entire shells of the same abundant species. The sand here is of a brown colour, most probably due to this fact. This is the finest outcrop of 'granulite' between Étel and the sea. Bolder cliffs occur, however, at Pont Lorois, about

[1] Geol. Mag., No. 547, January, 1910, p. 8.

[2] Prestwich, *Geology*, vol. i, p. 99. Minutes of Proceedings of the Institute of Civil Engineers, vol. xi, pt. ii, p. 4. For summary see Damon, *Geology of Weymouth*, p. 174.

3 miles northward. The height of the cliffs at Étel is about 30 feet. The corresponding outcrop opposite, across the river, is almost planed down to the level of the shore-sand.

Fig. 3 (Plate IX) gives the scanty ruins of the chapel of Ste. Brigitte looking northward across the river to Étel itself. The stones, as can be seen, are unmortared, and the whole building is of a primitive type of construction. Many shells of *Cardium edule* occur on the east side. With this we may compare the kitchen midden surrounding Constantine Church, Cornwall, and that near St. Piran's Church, Perranzabuloe, also in Cornwall, some scanty remains of which are still in evidence.[1] The narrowness of the door, with its stone lintel, and the absence of the arch are noteworthy. The date of the building probably approximates more nearly to that of St. Piran's first church, which was completely overwhelmed by blown-sand in the seventh century A.D.,[1] than to any later date.

The views (Plate IV, Geol. Mag. for January, 1910) were adapted by Miss Gertrude M. Woodward from French views, to the unknown authors of which, and to her, my thanks are due. I am also greatly indebted to M. Charles Garnier, of Étel, for invaluable help in kindly arranging and superintending the taking of photographs of all the principal points requiring illustration, a pleasant proof of the reality of the 'Entente Cordiale'.

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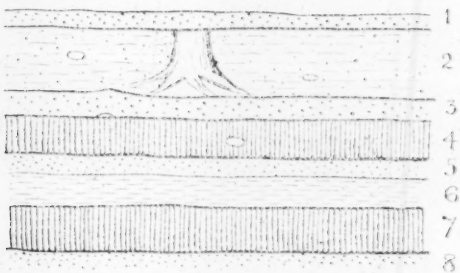
M. Cayeux gives the following section:—



1. Sable (·10 m.).
2. Sable tourbeux et tourbe avec souches (·55 m.).
3. Sable (·25 m.).
4. Tourbe banc supérieur à Roseaux (·40 m.).
5. Sable (·15 m.).
6. Tourbe (alluvion végétale) (·55 m.).
7. Tourbe, banc inférieur à Roseaux (·55 m.).
8. Sable (·10 m.).

[1] Proc. Malac. Soc., vol. viii, p. 247.

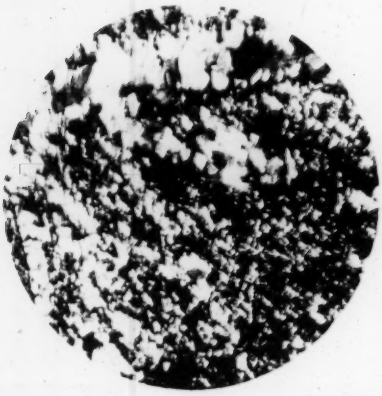


Fig. 1. ×20

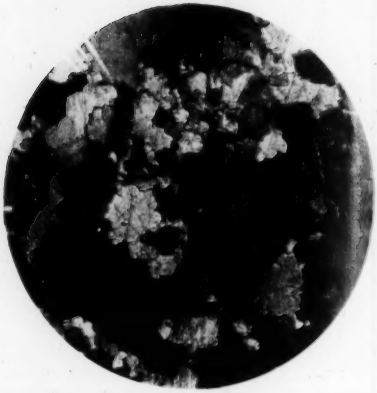


Fig. 2. ×20

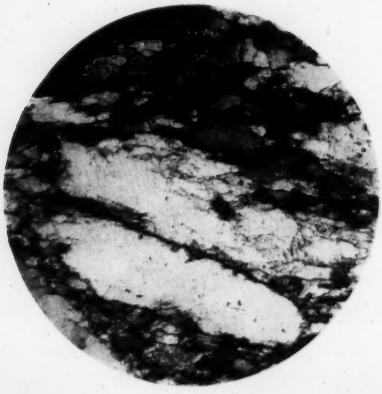


Fig. 3. ×20

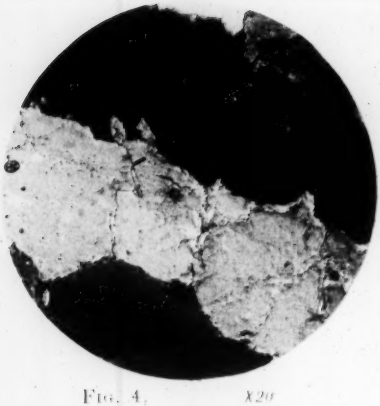


Fig. 4. ×20

Fig. 5. ×20

H. A. E. Photomicro.

Sections of Rocks from Etel, Brittany.

Notes.

2. Submerged forest (with tree-stumps): the soil is sandy and the vegetable matter is almost transformed into peat.
3. Gray quartz sands with traces of mica. Pebbles (rare) at base.
4. Peat (*Arundo phragmites*, L.), insect remains, elytra of Coleoptera.
5. Corresponds in material with 3.
6. Small branches of Poplar, Beech, Holly, and Hazel.
7. Peat. Insect-remains less common than in 4.

Bourlot, Jos. *Changement de niveaux des sols dans La Bretagne et la presqu'île Scandinave. Aire de deuxrellation dans le nord de l'Europe et de l'Asie*, 1865. Colmar. *Bull. Soc. Hist. Nat.*, 1867, 6 and 7, pp. 3–15.

EXPLANATION OF PLATES.

Plate IX.

Fig. 1. Cap de Garde.
,, 2. Cliff of Granulite, left bank R. d'Étel.
,, 3. Ruins of Ste. Brigitte, looking northward to Étel.

Plate X.

Sections of rocks (Figs. 1 to 4) from the Raised Beach at Étel, Brittany: prepared and described by Mr. R. F. Gwinnell, B.Sc. The photomicrographs were prepared by Dr. H. H. Arnold-Bemrose, M.A., F.G.S., under crossed nicols.

Fig. 1. Section of a very fine-grained rock with a foliated structure. × 20 diam.
,, 2. Section of a specimen much coarser in texture, the quartz-grains very irregular in shape and size. × 20 diam.
,, 3. This section shows distinct foliation and the groundwork of smaller grains with two elongated crystals of greater dimensions. × 20 diam.
,, 4. In this the rock-structure is coarser than in any of the others, all the grains large and most of them elongated, foliation is well seen. × 20 diam.
,, 5. A holocrystalline rock, hypidiomorphic without porphyritic constituents, texture of medium coarseness. (French 'granulite'.) × 20 diam.

II.—On Two Deep Well-Sinkings at Leckhampton Hill, Cheltenham.

By L. Richardson, F.R.S.E., F.G.S.

THOSE who are acquainted with the detailed zoning of the Upper Lias and Inferior Oolite of the Cotteswold Hills have long desired to know the precise date of the Upper-Lias deposit at Leckhampton Hill, Cheltenham, upon which the Inferior Oolite rests. At last the desired-for information is to hand. The Inferior Oolite at Leckhampton Hill rests directly upon the *Variabilis*-Beds of the Upper Lias.

It has, of course, long been known that there is no Cephalopod-Bed, like that so well known in the neighbourhood of Dursley, at Leckhampton Hill. All the evidence available tends to show that the *Scissum*-Beds rest directly upon the *Variabilis*-Beds. That would mean that the *Opaliniforme*-, *Aalensis*-, *Moorei*-, *Dumortieria*-, *Dispansum*-, *Struckmanni*-, *Pedicum*-, and *Striatulum*-Beds were absent from Leckhampton Hill, and that there is a considerable non-sequence there between the Inferior Oolite and Upper Lias. As regards the Cotteswold Sands alone, "there is a loss of about 140 feet from Coaley Wood to Leckhampton Hill" (S. S. Buckman, *in litt.*, November 11, 1909).

Unfortunately, the actual junction of the Oolite and Lias could not be investigated in the deep well from which the fossils indicative

of a deposit of *variabilis* hemera were obtained. The well had already long been made when the Birmingham Corporation acquired the Salterley-Grange Estate for the purpose of establishing a Sanatorium there for consumptives, and it had only to be cleaned out and deepened.

At all events, as far as can be gathered from evidence collected in the immediate neighbourhood, and what could be seen at the well-sinking itself, in the form of rock dug out, etc., the Inferior Oolite rests directly upon the greyish-blue sandy micaceous clays of *variabilis* date.

The well under consideration is situated between the two Hartley Cottages, which lie between Hartley Farm and the Sanatorium (see Map, Text-fig. 1). The site is now marked by the building that houses the pumping-engine.

Well at Hartley Cottages.—The well was commenced either in the *Clypeus*-Grit or Upper *Trigonia*-Grit. It is doubtful in precisely which, for about 60 yards along a trench that was dug for laying the pipes to connect another well (that in Hartley Bottom)

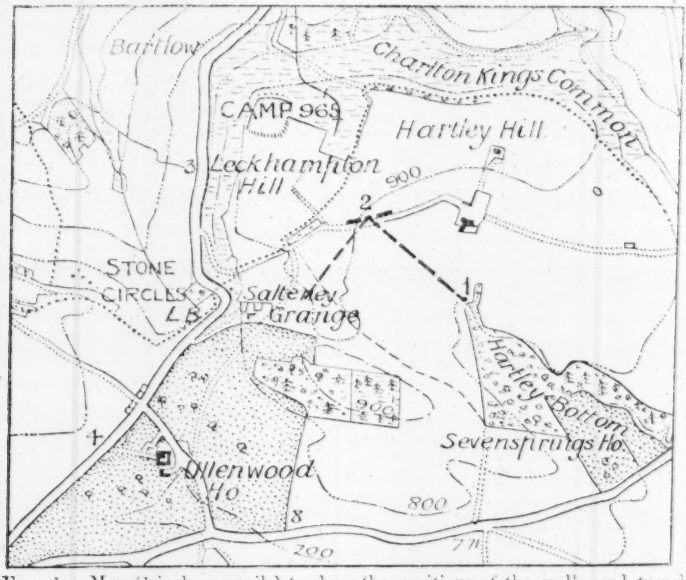


Fig. 1. Map (1 inch = a mile) to show the positions of the wells and trenches. (1) Hartley-Bottom Well; (2) Hartley-Cottages Well.

with this one, there appeared to be indications of a small fault, which brought the Upper *Trigonia*-Grit on the Hartley-Cottages well side into juxtaposition with the *Clypeus*-Grit.

From surface-level down to the top of the Upper Lias was 212 ft. 4 in. This thickness certainly includes a considerable portion of the Upper *Trigonia*-Grit. As the measurement made by me (*vide* Proc. Cotteswold Nat. F.C., vol. xv., pt. 3, 1906, p. 184) in the

large quarries on the escarpment gave about 200 feet as the thickness of the Inferior-Oolite deposit *between* the Upper *Trigonia*-Grit and the Upper Lias, the one total confirms the other.

The details obtained at the Hartley-Cottages well may thus be summarized:—

Well-Sinking at Hartley Cottages, Leckhampton Hill.

		Thickness in ft. in.	
Inferior Oolite.	*Clypeus*- and Upper *Trigonia*-Grits.		
	Beds between the Upper *Trigonia*-Grit and Upper Lias . . .	200	0
Upper Lias. *variabilis*.	1. Hard, greyish-blue sandy micaceous clay	3	9
	2. Yellow ferruginous, micaceous, indurated, sandy clay; *Nautilus*, *Belemnites* (phragmacones), small *Gryphææ* .	1	0
	3. Greyish-blue clay similar to 1	6	4
	4. More arenaceous but otherwise similar clay	1	0
	5. Greyish-blue sandy rock: *Belemnites* (near to *B. tubularis*, Y. & B.),[1] *Hungia grandis*, S. S. Buckman,[1] *Hungia* sp. indet.,[1] *Dactylioceras* cf. *Holandrei* (d'Orbigny),[1] *D.* cf. *micronatum* (d'Orb.),[1] *Thysanoceras* sp. (fragment: ? *T. sublineatum*, Oppel, sp.),[1] *Synecoloceras demissus*, (Phillips), auctt.,[1] *Pleuromya* sp.[1]	1	8
	Bottom of well (226 ft. 1 in.). Water ran away.		
	Boring.		
	6. Sandy clay	11	9
	7. "Very fine blue sand": penetrated	23	3

[In this well the water-level stood at 210 ft. 1 in., and did not rise on the well being deepened, but ran away at 226 ft. 1 in.]

I am indebted to Mr. S. S. Buckman for naming the ammonites.

In connexion with the same water-supply scheme that required the deepening of this Hartley-Cottages Well, a new well was sunk near the cottages at the northern entrance to the wood in Hartley Bottom; and two trenches were dug—the one connecting the Hartley-Bottom well with that at Hartley Cottages; and the other, the well at the latter place with the Sanatorium.

The sites of the wells and the courses of the trenches will be apparent from the small map (Fig. 1).

Well in Hartley Bottom.—This well was commenced in the Oolite Marl and left off in the Pea-Grit. Some of the pieces of Pea-Grit that were dug out were as blue as Forest Marble.

Pipe-trench connecting the Hartley-Bottom and Hartley-Cottages Wells.—As already remarked, there appears to be a very slight fault at some 60 yards along the trench away from Hartley Cottages in the direction of the Hartley-Bottom well. Thence onwards, however, to within 150 yards of the latter well the trench was in the *Clypeus*-Grit, which was full of the ordinary fossils.

Above the *Clypeus*-Grit exposed in the trench—especially about the middle portion—was a foot or more of tough, purplish clay—residual soil from the weathering of the Fullers' Earth. In the stretch from 150 yards of the well to the well itself, was observed evidence of the Upper *Trigonia*-Grit (? Gryphite-Grit), *Buckmani*-Grit, Lower *Trigonia*-Grit, and Upper Freestone.

Pipe-trench between the Hartley-Cottages Well and the Sanatorium.—For the first 300 yards this trench was in the Upper

[1] These specimens are now in the Cheltenham Town Museum.

Trigonia-Grit, but then, as the surface of the ground declined in the field just to the north of the Sanatorium-bungalows, the oyster-layer on top of the Upper *Trigonia*-Grit, the thin representative of the Notgrove Freestone (with bored and oyster-covered top-layer), and Gryphite-Grit were successively proved. Then came a small fault, the Fullers' Earth being let down against the 'Grit'. The Fullers' Earth, is, however, only a small mass, for the *Clypeus*-Grit rises up from beneath it but a few yards farther on, and is excellently exposed in the vertically-cut bank at the back of the bungalows.

I am indebted to Mr. J. W. Gray, F.G.S., of Cheltenham, for much of the information upon which this paper is based. He obtained the details of the Upper-Lias deposits exposed in the well, and collected the fossils that afforded the information as to their date.

III.—Notes on a pre-Tertiary Dyke on the Usway Burn.

By Miss M. K. Heslop, M.Sc.

(PLATE XI.)

A DYKE of pre-Tertiary age is exposed in the lower course of the Usway Burn, a tributary of the Coquet. It is intruded among the Cheviot igneous rocks, and crosses the burn in a somewhat north-easterly direction. In hand-specimens the rock appears black or dark brown with a sub-vitreous lustre, and contains porphyritic crystals which are quite visible to the unaided eye. It weathers a bright red colour and even the fresh portions are streaked with red veins of agate.

In his paper on the Cheviot Andesites and Porphyrites,[1] Dr. Teall mentions a rock allied to pitchstone-porphyrite, which is exposed on the Coquet about a quarter of a mile above Windy Haugh. The description he gives of it would serve very well for the Usway Burn Dyke, but he deals chiefly with the nature of the prevailing pyroxene, and not at all with the minute structure of the rock.

Under the microscope the porphyritic nature of the Usway Burn Dyke is at once evident, large phenocrysts of felspar and pyroxene being embedded in a rather dark glass crowded with elementary crystals. Between these two extremes is a medium-sized set of crystals, which may be referred to as the ground-mass generation. There are some rounded masses of a black oxide of iron which bear such evident traces of corrosion that they must be classed, with the porphyritic elements, among the products of an earlier period of crystallization. It is extremely difficult to determine the order in which the crystals were formed—particularly as the limits of the generations are very ill-defined—but there can be little doubt that the apatite needles and small grains of iron oxide, which are both included in the porphyritic crystals, are the oldest secretions of the magma. The porphyritic pyroxenes are older than the felspars by which they are frequently enclosed. So that in this, the first generation, the

[1] "Notes on the Cheviot Andesites and Porphyrites," by J. J. Harris Teall, M.A., F.G.S.: Geol. Mag., April, 1885.

minerals crystallized out in the following order: (1) and (2) apatite and iron oxide, (3) pyroxene, (4) felspar. The same order is preserved in the ground-mass generation, with the addition of a micaceous oxide of iron towards the close of the period. It is remarkable, however, that felspar laths of the normal ground-mass type are included in the porphyritic pyroxenes, and sometimes in the outer zones of the large felspars. At present there is no really satisfactory way of accounting for this apparent contradiction to the observed order of formation. In the last generation the elementary felspars take precedence of the pyroxenes, while much of the iron oxide still exists in an unindividualized state. There is apparently some overlapping of the periods of formation, but the crystals are classed chiefly by their state of preservation and their size.

The following figures give some idea of their relative dimensions. The first number in each bracket refers to the length, and the second to the breadth of the section.

Porphyritic felspars (1·14 × ·61 mm.), (1·96 × ·46 mm.), (1·32 × ·70 mm.) are of common occurrence, while (·43 × ·28 mm.) is very small.

Porphyritic pyroxenes, longitudinal sections: (1·4 × ·53 mm.) is large; (1·12 × ·18 mm.) and (·96 × ·50 mm.) are more usual; (·36 × ·24 mm.) is small. Some cross-sections are (·76 × ·71 mm.), (·39 × ·32 mm.), (·52 × ·50 mm.). Longitudinal sections of the ground-mass felspars vary from (·34 × ·18 mm.), which is unusually large, to (·035 × ·011 mm.); the average size is about (·12 × ·03 mm.). The largest cross-sections do not exceed (·12 × ·21 mm.), and are generally very much smaller. Longitudinal sections of ground-mass pyroxenes vary from about (·150 × ·180 mm.) to (·051 × ·027 mm.). When smaller than this they are commonly included among the elementary forms.

The *porphyritic felspars* may, for the convenience of description, be divided into three groups.

1. In the first are those with sharp angles, and clear, well-defined edges (see upper phenocryst in Figs. 1 and 2, Pl. XI). They are characterized by a combination of simple twinning with that of the albite type, e.g. one-half of a crystal may be untwinned while the other shows the ordinary albite striæ. Glass inclusions are common, but not conspicuous, and although traces of zoning have been observed, they are most indefinite, and entirely confined to the outer limits of the crystal.

2. A second set comprises those felspars which have a deep peripheral zone of glass inclusions, bounded by a complete though narrow zone of felspar material. These crystals are characterized by rounded angles and clear twinning of the albite type. They are usually made up of several particles, intergrown under plutonic conditions, apparently in some cases, then, *as a group*, furnished with a zone of glass inclusions and an outer felspar envelope, while at other times it is clear that these were added *before* the particles were grouped together, for each possesses complete zones of its own.

Sections of these groups *in* the zone of inclusions are apparently riddled with glass (see lower phenocryst in Figs. 1 and 2, Pl. XI).

and consist more of glass than of felspar, but the condition of the section does not necessarily indicate that of the whole crystal or crystalline group.[1]

3. The third set is characterized by deep zoning, sharp edges, few inclusions, and very indefinite twinning. Although distinct, these three types are probably due merely to different directions of the sections, or at most to slightly different physical conditions during growth. They do not imply three generations of porphyritic felspars.

The *ground-mass felspars* are broader and shorter than those which commonly occur in the post-Tertiary dykes of Northumberland and Durham.[2] They show a combination of binary and multiple twinning, and on the whole are very free from inclusions, although they do sometimes contain rounded or oval patches of dark glass, and are pierced by apatite needles. They are very markedly zoned.

The *porphyritic pyroxenes* are exactly like those which are described by Dr. Teall in the paper to which I have already referred. There he concludes that the prevailing pyroxene in the Cheviot Andesites and Porphyrites is not, as was previously supposed, *augite*, but *hypersthene*.

In the pyroxene of the Usway Burn Dyke, sections which are cut perpendicular to the prism are octagonal, but the pinacoidal faces are largely developed at the expense of those of the prism (see Figs. 5 and 6, Pl. XI). Cleavages parallel to both are usual, but that of the prism is the more distinct. These sections are decidedly pleochroic, the colour changing from yellow to reddish brown. They show straight extinction, and, in the vast majority of cases, a bisectrix in convergent light. Longitudinal sections, in which pleochroism changes the colour, from *green* for rays vibrating parallel to the length of the section, to *yellow*, for those vibrating at right angles to it, also show the point of emergence of a bisectrix, usually giving a much clearer figure than the cross-sections. They also show straight extinction. The cases in which an optic eye is obtained are various, but they generally have good traces of the brachypinacoids, and sometimes of the dome faces.

A combination of these sections gives a crystalline form like that described by Dr. Teall as a "columnar doubly-terminated crystal, which is made up mainly of the pinacoidal and only to a slight extent of the prismatic faces", while the consideration of the pleochroism and the interference figures shows that we are dealing with a crystal in which the axes of elasticity coincide with the crystallographic axes, so we are justified in assuming that it is orthorhombic. That it is hypersthene and not enstatite or bronzite is shown by the strong pleochroism, and the constant occurrence of the clearest interference figure (bisectrix) in the least pleochroic sections (green and yellow), and the occurrence of a less definite figure in the normal

[1] Teall, Geol. Mag., 1887, "Notes on Cheviot Andesites and Porphyrites," p. 150: "In this case the bulk of the foreign matter must be greater than that of the felspar substance, and yet the felspar has impressed its character on the compound mass."

[2] Teall, Q.J.G.S., 1884, p. 229.

transverse sections—in other words, the acute bisectrix coincides with the brachydiagonal and the crystals are negative. These are the characteristics of hypersthene.

Dr. Teall claims that a monoclinic pyroxene is also present in the Cheviot igneous rocks, and mentions twinning (parallel with the pinacoids) which, he suggests, only takes place in the monoclinic mineral. Twinning parallel both to the prism and pinacoids may be seen in the Usway Burn pyroxene, but it is found sometimes in crystals which are undoubtedly orthorhombic. There are, however, certain sections noticeable in ordinary light for their irregular outlines, deep cleavage, and dark colour—but little changed by pleochroism—and between crossed nicols for their brilliant interference colours and frequent twinning. There can be little doubt that they are monoclinic crystals of augite. Sections perpendicular to the prism give, in convergent light, a dark arm surrounded by coloured bands. Sections parallel to the prism give various and somewhat doubtful figures, never a good bisectrix.

In a much decomposed specimen of the rock, all the large well-formed pyroxenes are altered to colourless masses streaked with green fibres of chlorite, and including little dark rods. Patches of the original mineral may sometimes be found towards the centres of these crystals, and in one or two cases the fresh portion was distinctly twinned. It would be difficult to say, in these circumstances, whether the fresh portion is orthorhombic or monoclinic, but that the whole crystal was originally orthorhombic is beyond question. In this altered specimen the only wholly fresh crystals are those described above as augite, and although some orthorhombic sections are only partially decomposed, they belong to the ground-mass generation. It would seem, then, that both orthorhombic and monoclinic pyroxenes are present, but that the former is either *older* or *more readily decomposed* than the latter; also that twinning is common to both, and is probably, in the orthorhombic mineral, a precursor of decomposition, perhaps of optical re-orientation.

It is difficult to draw a definite line between the porphyritic and ground-mass pyroxenes. The latter, unlike the felspars of their own generation, occur in exactly the same way as their porphyritic equivalents. They are always surrounded by a little halo of pale yellow material with which the incomplete crystals (of common occurrence) are intergrown in a way that recalls the micro-pegmatitic intergrowth of quartz and felspar (see photographs 5 and 6). There is no clue, however, to the identity of the intergrown substance in the case we are considering, for although it is not absolutely isotropic, its interference effects are too feeble to be of any use. These incomplete crystals may be correlated with the incomplete prisms of the third generation, a description and suggested explanation of which is given later.

In a decomposed specimen of rock, the pale zones surrounding altered pyroxenes, both large and small, become very conspicuous, and contain tiny prisms of the fresh mineral, lying with their axes parallel to those of the large crystals to which they are attached.

The Glassy Base.

With low powers it looks as though the porphyritic and ground-mass crystals were embedded in an almost homogeneous dark-brown background; but when the latter is examined with higher powers, it appears that the ultimate base is colourless and contains numbers of brown patches which give the characteristic colour. These patches have borders of a yet darker hue (see Fig. 4, Pl. XI), and from their corners send out processes into the clear base. The highest powers cannot resolve the brown areas into any constituent part, but it may readily be seen that the dark edges are due to numbers of globulites which also form the processes, being carried out apparently on a central thread of material from the patch.

The dark areas show a marked tendency towards angularity of shape, many are rectangular, while others have more hexagonal outlines. They are considerably deformed by the protrusion of the globulitic processes, which, besides obliterating the corners, curve the sides. Some are quite shapeless. The colour of the glass is greatly intensified by numbers of small reddish-brown hexagons of a micaceous oxide of iron, probably hæmatite (see Fig. 4 in Plate). These little plates are never very thick, for sections perpendicular to them always give quite narrow dark needles. Irregular grains of a black oxide of iron are fairly common. They have never been known to show any definite crystalline form, and are probably in a very elementary stage of development. Crystals of the iron oxides, like those of the pyroxene (see Fig. 5, Pl. XI), are surrounded by light-coloured areas when embedded in a dark patch. Apatite is repeated in this generation in small but very perfect needles, which pierce all the other crystals and are certainly older than most of them, although the precise relation of their age to that of the apatites of earlier periods of crystallization is somewhat obscure. The early felspars are of the same type as those of the ground-mass. The crystals in this case, however, are only solid at the centre, and grow in hollow tubes in both directions, consequently longitudinal sections show the well-known 'hour-glass' structure (see Fig. 3, Pl. XI), while cross-sections of any but the central part show square colourless frames of felspar material filled with glass. No globulitic stage of felspar growth has yet been seen, the very earliest recognizable forms being faint colourless streaks, only visible when surrounded by dark glass.

The simplest elementary pyroxenes are short cigar-shaped prisms which occur either in pairs or groups, rarely alone. All possible combinations of these have been observed. The pairs are attached at their centres, while the ends of both curve away from each other, thus imitating the 'hour-glass' structure of the felspars. Some assume the usual skeleton form, consisting of a central stem with little perpendicular arms attached on either side; others adopt the curving acanthus-like structure which is so strongly developed in the Collywell and Crookdene Dykes of Northumberland.[1]

[1] "Notes on the Crookdene and Related Dykes," by M. K. Heslop, M.Sc., and Dr. J. A. Smythe, read before the Geological Society, November 17, 1909.

The largest elementary pyroxenes are prismatic in shape, and they appear to grow by the addition of material at the corners, and it is remarkable that quite detached particles are often arranged *in line* with each other and with the edge of a small pyroxene, for considerable distances. In one case a 'process', about ·0375 mm. in length, protrudes from the end of a small prism of pyroxene, and is made up of several apparently quite detached particles. The intervals between them are too minute to be correctly estimated—it is quite evident, however, that each piece is separate.

This kind of growth seems to prevail among the elementary pyroxenes, because, not only are there innumerable examples of it, but in the more advanced crystals cross-sections with good octagonal forms and sharp angles often show a gap filled with glass running across the centre of the section almost at right angles to the pinacoids (see Figs. 5 and 6, Pl. XI). If we refer again to the simplest elementary pyroxenes, those consisting of two cigar-shaped needles joined at the centre, but with tapering ends diverging apart, we see that there is a tendency for pyroxene to grow in incomplete, perhaps hollow, prisms from a solid centre, as in the case of the 'hour-glass' felspars. This, no doubt gives rise to the centrally incomplete sections which have just been described, and to the intergrowth of pyroxene with the pale yellow material—again in incomplete crystals—which occurs in the ground-mass generation (see description of ground-mass pyroxenes). The gaps are always filled by this pale yellow, feebly doubly-refracting substance, which seems indeed to have been brought almost to a crystallizable state by the subtraction of pyroxene material to build the crystals of that mineral.

In one slide the glass is in a much more developed stage. The base is still colourless, but there is a marked increase in the number of elementary crystals, especially the iron oxides and the little pyroxene needles. The brown patches have practically disappeared, but their final stages may be recognized in the small clouds of dark granules which are usually associated with elementary pyroxenes.

A practically unbroken transition from the dark granules to definitely hexagonal plates of micaceous iron oxide has been made out. With a magnification of 1000 diameters, very small granules may be seen to possess hexagonal outlines, and although many may belong to the black oxide, there can be little doubt that the brown patches of the normal glass are here very largely represented by hexagons of micaceous oxide of iron.

In the same way, and with equal certainty, a transition from the globulitic processes of the brown patches to the elementary cigar-shaped pyroxenes may be traced. These may be certainly identified by their interference colours, needles with a thickness of less than ·00236 mm., giving quite recognizable interference tints. It is impossible to say definitely whether these early forms are orthorhombic or monoclinic, but the number of cases in which the extinction is *oblique* suggests the latter.

The association of pyroxene and iron oxide in the brown patches is similar to the association of the basic elements, augite and iron oxide, in the 'basic globulite' of the post-Tertiary Dykes of Northumberland.

A careful study of the mode of occurrence of elementary crystals in them shows that the growth of a skeleton augite is almost invariably accompanied by the elimination of iron oxide at intervals along the stem and arms of the skeleton crystal. *Here*, the reverse occurs. The brown patch (which may be regarded as an enlarged basic globulite) contains the ingredients both of the pyroxene and iron oxides, the latter apparently in excess of the former. The pyroxenic constituent separates out in globulitic forms, segregates at the edges of the patches, and is gradually eliminated as the globulitic processes break off and become definite elementary pyroxenes. It is not suggested that after this the brown patch merely assumes hexagonal outlines—although its somewhat marked angularity seems to indicate an inclination to do so. The process is, no doubt, much less simple, and must involve a differentiation between the hæmatite and the black oxide of iron; but it is certain that these minerals do assume a more or less definite crystalline form after concentrating as much as possible, and so eliminating the pyroxenic material.

EXPLANATION OF PLATE XI.

ROCK-SECTIONS, PRE-TERTIARY DYKE, USWAY BURN.

FIG. 1. This shows the general structure of the rock. There are two types of porphyritic felspars: the upper one belongs to the first set, and has few inclusions and clear sharp angles and edges. The lower one has rounded angles and is riddled with inclusions: it belongs to the second set. × 22·6 diameters.

„ 2. Shows the same field between crossed nicols.

„ 3. This shows the mode of occurrence of the elementary felspars. The 'hour-glass' structure is well seen in the small longitudinal section which occurs near the centre of the field. × 260 diameters (approx.).

„ 4. This emphasizes the dark borders of the brown patches, and shows the globulitic nature of the processes. In the centre of the field there is a small hexagon of the micaceous iron oxide, in which different thicknesses (due to incomplete cleavage-plates) have produced different intensities of colour. × 260 diameters (approx.).

„ 5. An incomplete pyroxene is seen here. Although it occurs in a dark patch, it is surrounded by a zone of light-coloured material, which also fills the gap extending across the centre of the crystal. There are several small detached pieces of pyroxene near the lower left-hand corner of the crystal. × 208·3 diameters (approx.).

„ 6. Shows the same with nicols crossed. This brings out clearly the isotropic nature of the colourless material which forms the zone and the central inclusion.

IV.—NOTE ON A MOUNTED SKELETON OF A SMALL PLIOSAUR, *PELONEUSTES PHILARCHUS*, SEELEY, SP.

By C. W. ANDREWS, D.Sc., F.R.S., British Museum (Natural History).[1]

(PLATE XII.)

THE skeleton figured on Plate XII is that of a small Pliosaur, *Peloneustes philarchus*, Seeley, sp. This specimen was obtained from the Oxford Clay in the neighbourhood of Peterborough by Mr. A. N. Leeds, F.G.S., to whom the British Museum is indebted for a great series of more or less perfect skeletons of many species of

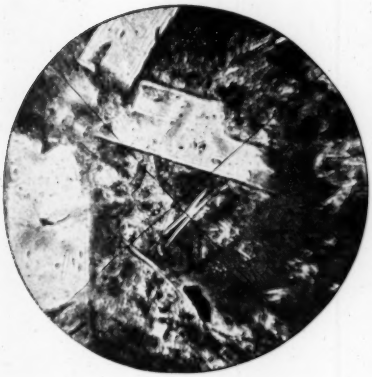
[1] Published by permission of the Trustees of the British Museum.

1

× 22·6

2

× 22·6

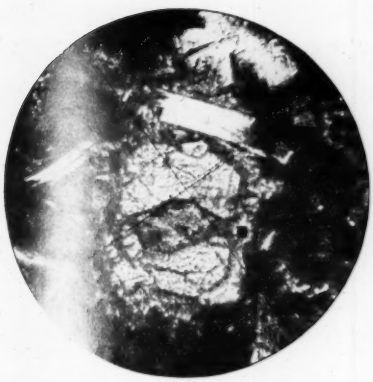


3

× 260

4

× 260



5

× 208·3

6

× 208·3

Rock-sections from pre-Tertiary Dyke, Usway Burn.

Oxford Clay Reptiles, including the beautifully preserved and nearly complete examples of *Cryptocleidus oxoniensis* and the remains of *Cetiosaurus leedsi*, now mounted in the Gallery of Fossil Reptiles. So far as I am aware, this is the first skeleton of a Pliosaur that has been mounted so as to show the true form of the body in those reptiles. All the bones belong to a single individual, but the left-hand paddle and the distal portion of the other paddles being wanting, they have been represented by plaster models made from the paddles of another individual, which are exhibited on the floor of the case. The left ischium has been modelled from that of the opposite side.

Peloneustes philarchus was first noticed by the late Professor H. G. Seeley[1] under the name *Plesiosaurus philarchus*. Subsequently Mr. Lydekker[2] gave a more complete account of the species and referred it to a new genus, *Peloneustes*. The structure of the skull was described by the present writer in the Ann. Mag. Nat. Hist., 1895, ser. VI, vol. xvi, p. 242.

Peloneustes, though considerably smaller than the other Pliosaurs, exhibits all the characters peculiar to that family, viz. relatively large head, short neck with double-headed cervical ribs, absence of a median symphysis of the scapulæ, greatly elongated ischia, and hind paddles larger than the fore. Mr. Lydekker, however, considers that in some respects it is more primitive than the larger forms, and tends to bridge the gap between them and the true Plesiosaurs.

The skull, which in the present specimen is somewhat crushed and distorted, is relatively large and the snout is considerably elongated, the length of head being about two and a half times its width at the posterior end. There are six teeth in the premaxilla, and twenty-eight to thirty in the maxilla; in the lower jaw there are about thirty-five teeth on each side, of which fifteen to sixteen are in the symphyseal region. The teeth themselves are slender and sharp-pointed; they are circular in section, and the enamel-covered crown bears numerous fine longitudinal ridges, some of which extend to the apex. The neck is short, and is composed of twenty-one or twenty-two vertebræ, including the atlas and axis; the centra are short and slightly biconcave, the neural arches and spines are high. All the cervicals behind the united atlas and axis, with the exception of the last, bear double-headed ribs, but the facets for the upper and lower heads are separated by a slight ridge only; the last cervical seems to have had only one head, and the same is the case with the pectorals and dorsals. Of these there seem to have been two or three of the former and twenty-two or twenty-three of the latter, all bearing comparatively slender ribs. The number of sacral and caudal vertebræ is not definitely known.

The shoulder-girdle is typically Pliosaurian, the coracoids are large thin sheets of bone; the scapulæ are triradiate, but the ventral rami do not meet one another in the mid-ventral line, nor do they meet the coracoid. Some specimens show that a triangular interclavicle was interposed between the ventral ends of the scapulæ. The fore paddle

[1] *Index to Aves, etc., in the Cambridge Museum*, 1869, p. 139.
[2] Quart. Journ. Geol. Soc., 1889, vol. xlv, p. 48.

is smaller than the hind; the humerus is only slightly expanded at its lower end, and the rest of the paddle is long and slender. The pelvis consists of small rod-like, backwardly sloping ilia, great thin plate-like pubes, and the greatly elongated ischia characteristic of the family. As usual in the group, the ilium is not in contact with the pubes in the acetabulum. The greatly expanded coracoids, pubes, and ischia formed an almost continuous bony floor to the body, and the short interval between the posterior edge of the coracoids and the anterior edge of the pubes was filled by a plastron of ventral ribs; in the mounted specimen this is represented only by three of the median ventral ribs, which are fused with one another on the middle line.

The hind paddles, though larger, are closely similar in form to the fore paddles. The total length of the specimen as mounted is 11 ft. 6 in. The dimensions in centimetres of some parts of this skeleton are—

Skull, length	55·7	centimetres.
Mandible, length	67·0	,,
,, length of symphysis	21·4	,,
Coracoid, greatest length	47·0	,,
Humerus, length	35·0	,,
Pubes, length	33·8	,,
Ischium, length of median expansion	57·9	,,
Femur, length	39·0	,,

V.—Glacier Granule-markings.

By R. M. Deeley, M.Inst.C.E., F.G.S.

(PLATE XIII.)

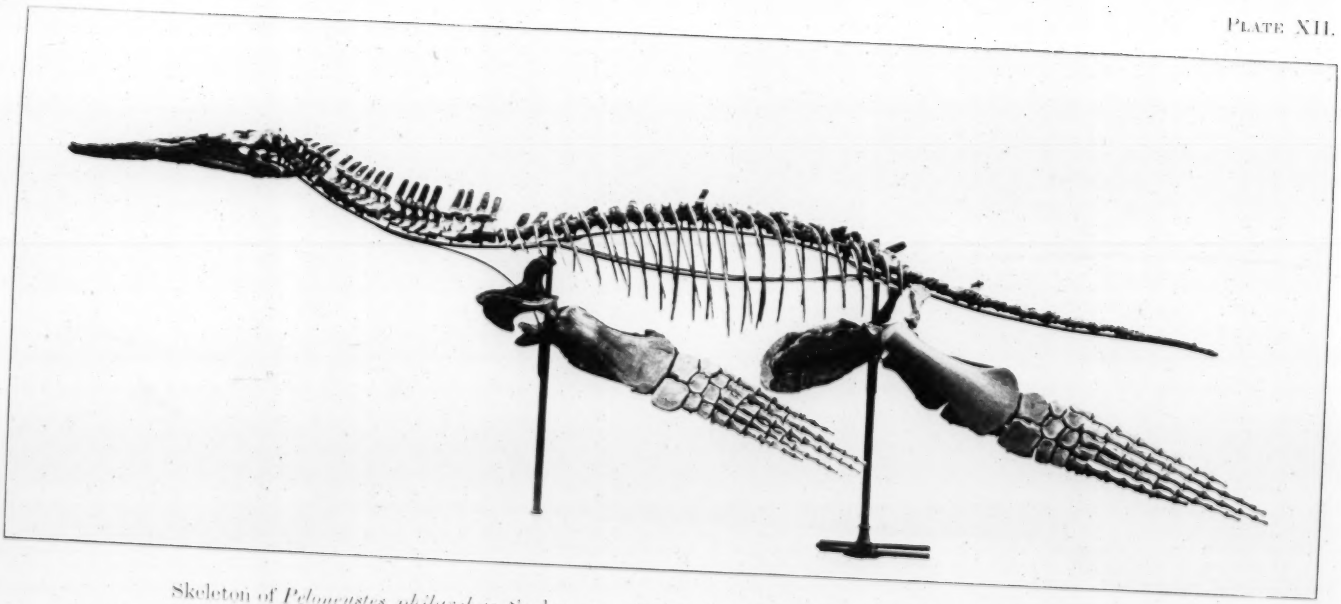
I HAVE already described the granular appearance of glacier ice as seen in polarized light[1] and also the striations on the granules as shown by pencil rubbings.[2] Last summer I succeeded in obtaining exact reproductions, in plaster of Paris, of the ice surface-structure in the upper cave in the Rhone Glacier. These are shown in Figs. 1–3.

The casts were obtained in the following manner. Plasticene, a substance used for modelling, having been cooled to the temperature of the ice, was pressed against the wall of the cave. When all the conditions were favourable the surface of the plasticene took an exact impression of the ice-surface. A cardboard ring, obtained from a pillbox, the top and bottom of which had been removed, was then pressed upon the surface of the plasticene and filled with liquid plaster of Paris. When the plaster had properly set the plasticene and cardboard were removed. Photographs of these casts, as will be seen from the photos reproduced, give very good representations of the ice markings (see Plate XIII).

A careful examination of well-marked granules in which liquid cavities had been produced by a burning-glass showed that the ridges and furrows in each grain were along planes at right angles to the optic axes of the granules. It is clear, therefore, that the direction of the markings is determined by the crystalline structure of the ice.

Fig. 2 is a print of a portion of the surface of a large glacier granule, and Fig. 1 shows portions of several granules. Fig. 3 is

[1] Geol. Mag., 1895, p. 152. [2] Ibid., 1907, p. 529.



Skeleton of *Peloneustes philarchus*, Seeley, sp. Oxford Clay, Peterborough. About $\frac{1}{20}$ natural size.

a still further enlargement of a portion of Fig. 2 to show more clearly the details of the surface-structure. It will be seen that both the ridges and the furrows frequently bifurcate, and that whilst maintaining their general direction across the granules they curve about considerably. Fig. 1 shows several granules abutting against each other. The most marked feature is that some of the surfaces of the granules occupy depressions, whilst others project above the general level of the surface. The surface was originally quite level, and evaporation and melting have taken place on the surfaces of some of the granules more rapidly than upon others. The coarseness of the grooving on different granules varies somewhat. In Fig. 1 all the granules differ in this respect. Compare the fineness of the grooving on the larger granule with the coarse incipient grooving on the top one.

The rubbings I had previously obtained seemed to show that even when protected from the sun, as in a cave, each granule was separated from its neighbour by a canal of more or less width. These actual impressions, however, make it clear that this appearance was produced by the pencil passing from raised to depressed granule surfaces and vice versa. Sometimes the grooving of the surface of the lower crystal is not well marked near its junction with other granules. This is probably the result of capillary forces causing water to collect along the line of junction. Evaporation rather than melting appears to be the main cause of the appearance of the surface-structure we are considering. It occurs at all points in caves both in the light and in the dark. Ventilation appears to have the most marked effect on its appearance; for the surface-markings were very well developed in many of the crevasses intersecting the ice cave.

I have never seen the structure on lake ice, pieces of which have been exposed in a freezing atmosphere. Shear planes in the granules, produced by the differential motion of the glacier might produce the ridges and furrows. O. Mugg[1] says "broken surfaces, *especially those of bent bars of ice*, almost always show a fine striation". With regard to McConnell's work on the bending of ice Mugg[2] says, "As McConnell died during these experiments I decided to take them up again, and especially to make the experiment to produce in the ice the pure translation without curvature and also if possible to ascertain the direction of the translation." "The result was a complete confirmation of McConnell's experiments." Mugg's investigation was a very exhaustive one from the point of view of the chemist and crystallographer.

The microscopical examination of polished surfaces of alloys which have been sheared shows that the distortion takes place along definite shear planes in the crystals and not equally throughput the mass, as in amorphous liquids. Crystalline ice, it would appear, also shears along definite planes, and the distortion in the crystalline structure along such planes results in differences of surface evaporation, which give rise to the surface ridges and furrows.

[1] *Jahrb. für Min.*, 1895, p. 217.

[2] Ibid., pp. 213, 214.

From these considerations it appears that the differential motion of glaciers is partly the result of viscous shear between adjacent granules; partly of viscous shear along planes at right angles to the optic axes of the crystalline granules; partly of the plastic shearing into separate pieces of the granules and to the viscosity imparted to the general mass by the growth of one crystal at the expense of another. It is to this latter giving way of the points of attachment between granule and granule, owing to molecular movements at their interfaces, that the general viscosity of the glacier depends. The deformation of the granules by stress and the formation of extensive shear planes by the breaking up of granules are secondary effects.

EXPLANATION OF PLATE XIII.

Fig. 1 shows a portion of the ice surface, consisting of several granules, in the Upper Cave of the Rhone Glacier, magnified 2·5 diam.

Fig. 2 shows the surface of a large granule in the same cave, magnified 2·5 diam.

Fig. 3 shows an enlargement of a portion of the surface of the granule in Fig. 2, enlarged to 10·8 diam.

VI.—Some Fossil Annelid Burrows.[1]

By Dr. F. A. Bather, M.A., F.R.S.

IN the little note on "Fossil Representatives of the Lithodomous Worm *Polydora*" which appeared in the Geological Magazine for March, 1909 (pp. 108–10), it is said that, "so far as I can ascertain, this genus has not hitherto been recorded in a fossil state." It has since come to my knowledge that I was not the first so to record it, and I therefore ask permission to make the necessary emendation.

In March, 1908 (Bull. Soc. géol. France, ser. 4, vol. vii, pp. 361–70, pl. xii), Professor Henri Douvillé published a paper on "Perforations d'Annélides", in which he figured a surface of Jurassic rock, from near the fort of Arrabida in Portugal, penetrated by burrows characteristic of *Polydora*. Since these Jurassic rocks are covered by others of Helvetian age, the borings cannot be of later date than Middle Miocene. These perforations, which were first observed by Mr. P. Choffat (December, 1906, Bull. Soc. géol. France, ser. 4, vol. vi, p. 237), are about twice as large as those of *Polydora ciliata*, and are therefore compared by Professor Douvillé with those of *P. hoplura* Claparède. He adds: "On pourrait réserver à ces perforations la terminaison *ites* et les désigner sous le nom de *Polydorites*." Since no distinction can be drawn between the borings thus named *Polydorites* and those made by *Polydora*, it appears that 'Polydorites' is not intended as an independent generic name, but merely as a brief way of writing 'fossil traces of *Polydora*'.

Polydora hoplura is a British species, though not so common as *P. ciliata*. Others placed in the British list by Professor W. C. M'Intosh (February, 1909, Ann. Mag. Nat. Hist., ser. 8, vol. iii,

[1] Published by permission of the Trustees of the British Museum.

x25

FIG. 1.

FIG. 2. x25

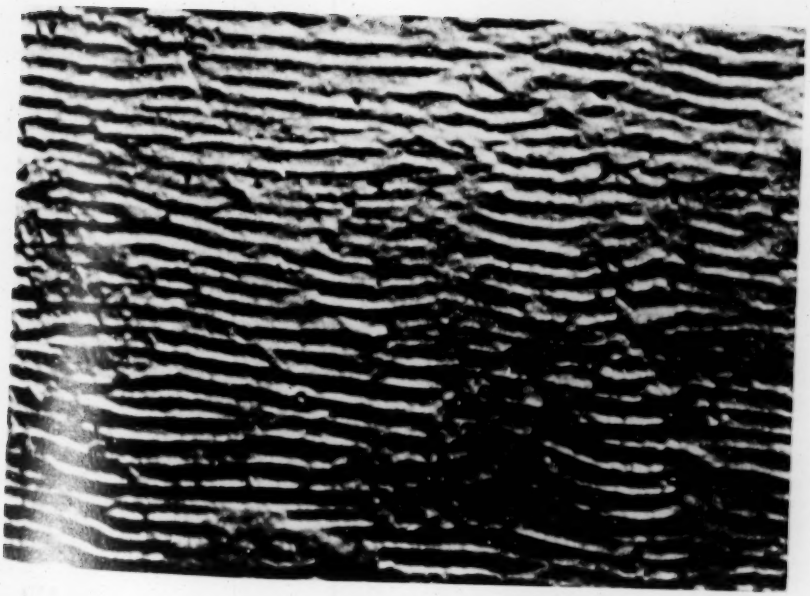


FIG. 3. *Benrose, Colls.*

Striations on Glacier Granules.

pp. 169–74) are *P. caeca* Oersted, *P. flava* Claparède, *P.* cf. *quadrilobata* Jacobi, and *P. Carazzi* n.sp.

Professor Douvillé is inclined to refer to an annelid of the same Family (Spionidæ) some U-shaped galleries described by Professor Carlos I. Lissón (1904[1]) under the name *Tigillites Habichi* n.sp. These occur in stratified quartzites around Chorillos, south of Lima (Peru), and are assigned by Professor Lissón to a post-Neocomian but pre-Tertiary age, because the quartzites are covered (though not quite conformably) by nodular and vari-coloured quartzites containing ammonites which he refers to *Sonneratia*. Mr. G. C. Crick does not consider that the figures and descriptions warrant this reference, and he inclines to agree with Mr. W. M. Gabb, who regarded the ammonite described by himself from this horizon as of Kimmeridgian or Corallian age. However this may be, Professor Douvillé seems to have made a slip in calling these rocks "quartzites paléozoiques des environs de Callao."

While it seems probable that these tubes are not congeneric with the somewhat larger palæozoic *Tigillites*, there are objections to classing them with the smaller *Polydora*. The latter annelid makes littoral or inter-tidal borings into the hardened rocks of the shore. The tubes of *T. Habichi*, on the other hand, were formed in soft sand, *pari passu* with its deposition, a fact clearly indicated by their upward passage through successive laminæ, and the successive withdrawals of the curved bottom of the U to a higher level. The mere fact that weathering occasionally reduces the double opening of the tube to a single more or less keyhole-shaped opening, as in *Polydora*, is not enough to outweigh these differences.

That a keyhole-shaped opening is not in itself sufficient evidence of the work of *Polydora* follows from the studies of Dr. D. Carazzi on "La perforazione delle rocce calcaree per opera dei datteri (*Lithodomus dactylus*)" (1892, Atti Soc. Ligustica, iii, pp. 279–97), where it is shown that the aperture of the burrow, at first circular, soon assumes an elliptical outline, which eventually becomes constricted along the minor axis, until the shape is almost that of an **8**, with one half smaller than the other. The fragment of bored rock-surface, as figured by Dr. Carazzi on a reduced scale (p. 293), forcibly recalls the traces of *Polydora*. But the burrows have no septum to give them a U-shape, and their natural size (to judge from specimens in the British Museum) is about half-an-inch along the major axis.

Professor Douvillé, accepting the views expressed by Mr. Clifton J. Sarle in February, 1906,[2] proceeds to discuss some forms hitherto referred to *Taonurus*. Mr. Sarle came to the conclusion that *Arthrophycus* Hall, *Dædalus* Rouault (= *Vexillum* Rouault), *Taonurus* Fischer-Ooster (= *Spirophyton* Hall, *Alectorurus* Schimper, *Physophycus* Schimper, *Cancellophycus* Saporta, *Glossophycus* Saporta & Marion) were traces of burrows formed by sedentary Polychæta in rather

[1] "Los Tigillites del Salto del Fraile y algunas Sonneratia del Morro Solar: contribución á la geología de los alrededores de Lima," Bol. Cuerpo Ingen. de Minas Perú, No. 17, 64 pp. Lima, 1904.

[2] "Arthrophycus and Dædalus of Burrow Origin," pp. 203–10; and "Prel. Note on the Nature of Taonurus", pp. 211–4: Proc. Rochester Acad. Sci. iv.

loose sedimentary rock of various ages. He also referred to *Taonurus* some traces previously placed under *Taonichnites* (*Medusichnites*) Matthew and *Zoophycos* Massalongo. And with all these forms he compared *Dictyodora liebeana* Weiss, *Arenicolites duplex* Williams, and *Rhizocorallium* Zenker (= *Glossifungites* Lomnicki). As regards the last-mentioned genus, to which he referred forms included under *Taonurus* by Saporta and others, Mr. Sarle wrote that they "were produced by the packing of sediment along the radial side of a reclining U-shaped burrow of two openings, as it was repeatedly shifted and lengthened". The forms discussed by Professor Douvillé are *Taonurus ultimus* Saporta & Marion, Miocene, *T. Panescorsei* Saporta and Marion, Trias, *T. Saportai* Dewalque, Senonian. The last-mentioned, at all events, occurs on the worn surface of the Chalk, and the burrows are filled with silica and glauconite from the overlying Landenian. Professor Douvillé regards the burrows as hollowed by a Spionid of large size living in the Lower Eocene sea. On account of their form he separates them from *Taonurus*, and adopts the name *Glossifungites* Lomnicki (1886, Sprawozd. Kom. fizyjog. Akad. Umiej. Krakowie, xx, p. (99), pl. iii, f. 64) of which the genotype is *G. saxicava* of Miocene age. If, however, this last is really the same as *Rhizocorallium* Zenker (1836, "Historisch—topogr. Taschenb. v. Jena", pp. 202–19), then that name must be preferred. The genetype is *R. jenense* Zenker (locc. citt.) occurring at the base of a thin bed of dolomite in the Bunter Marls near Jena.

A good account of the older literature bearing on these curious forms will be found in the well-known memoir by S. Squinabol, "Alghe e Pseudoalghe fossili italiene" (1890, Atti Soc. Ligustica, i, pp. 29–49, 166–99). Most of them have generally been referred to a supposed Family of Algæ, the Alectoruridæ. These have previously been discussed by Professor Th. Fuchs, who has recently accepted the views of Sarle and Douvillé (December, 1909, Mitt. Geol. Ges. Wien, ii, pp. 335–50) and has extended a similar explanation to such forms as *Vexillum Morieri* Sap., *V. Rouvillei* Sap. (= *Phycodes circinnatus* Richter), *V. Desglandi* Rouault, *Chondrites flabellaris* Sap., and *C. affinis* Sternb. In short, it seems probable that a large number of forms previously placed by geologists in a convenient receptacle labelled 'Fucoids' may now be safely regarded as due to burrowing annelids. I am not, however, prepared as yet to agree with Professor Douvillé that those annelids belonged to the family Spionidæ.

Mr. Linsdall Richardson, who discovered in the Rhætic conglomerate the bored pebble described in my previous note, seems subsequently to have found further examples, for he says in a report of an "Excursion to the Frome District, Somerset" (October, 1909, Proc. Geol. Assoc., xxi, on p. 223), that the conglomerate contains "pebbles of chert and Carboniferous Limestone that were well bored by the Lithodomous *Polydora ciliata* (Johnston)". I must repeat my opinion that "the worm . . . may well have been a *Polydora*, but it was not *P. ciliata*".

VII.—On the Horizon of the Lower Carboniferous Beds containing *Archæosigillaria Vanuxemi* (Göppert) at Meathop Fell.

By Professor E. J. Garwood, M.A., Sec. Geol. Soc.

In a note on *Archæosigillaria Vanuxemi* and *Bothrodendron* sp., published in the Geological Magazine for February last, Mr. J. W. Jackson speculated on the age of the beds at Meathop, in which these plant remains occur, and refers to the general classification of the Lower Carboniferous rocks of the Westmorland district, which I gave in this magazine in 1907.[1] He remarks: "It is perhaps premature to attempt to fix definitely the exact horizon of these beds, as they appear to have been as yet but superficially studied."[2] Since the classification above referred to was published, I have devoted such time as could be spared from professional duties to an exhaustive examination of the whole northern area, the result of which has been to confirm the general conclusions already given in this magazine. In my forthcoming account of the district, I have given a detailed description of the Meathop section. The delay in publishing a full account of the northern area has been necessitated by the general structure of the district, which required a careful study of isolated outcrops, extending over a very large area, before an accurate co-ordination of the separate exposures could be established. If any justification for this delay were needed, it is supplied by Mr. Jackson's note, in which he confesses his inability to decide upon the age of the beds displayed in the isolated exposure at Meathop on the evidence afforded by the collections obtained during his visits to that locality.

On my first visit to this section some years ago I obtained only a scanty fauna, giving inconclusive evidence of the horizon, and it has required very careful and close collecting during repeated visits before the beds could be definitely correlated with those occurring in other portions of the district where the horizons could be accurately determined. Pending the publication of my detailed description it may therefore be of interest to give here the conclusions arrived at regarding the age of the Meathop beds and the evidence upon which it is based.

My further work in the district since the provisional classification was published proved conclusively that the Meathop beds were correctly correlated with the lower dolomites of Shap and Brigsteer, and represent the lower portion of Dr. Vaughan's C horizon in the Bristol area. This is clearly shown by a comparison of the Meathop fauna with that of the beds in the Shap exposures. In my previous notes I laid emphasis on the importance of the Arnside *Michelinia* bed as furnishing a definite horizon in the northern sequence, and regretted the absence of beds containing this characteristic fauna from the Shap district. At the same time I gave evidence in support of the contention that the *Michelinia megastoma* bed must be represented in that district by the base of the Ashfell Sandstone, or by the top of the Shap dolomite. This contention has now been fully corroborated by the finding of *Michelinia* itself in the *Camarophoria isorhyncha*

[1] Geol. Mag., 1907, Dec. V, Vol. IV, pp. 70–4. [2] See table, op. cit., p. 73.

bed in the lowest layer of the Ashfell Sandstone of the Shap area; the further interesting discovery two years ago of *Michelinia megastoma* with *Camarophoria isorhyncha* on the summit of Meathop Fell no longer leaves any reasonable doubt as to the horizon to which these beds belong.

Mr. Jackson mentions the occurrence of *Spirifer* cf. *furcatus* (McCoy) and *Productus* aff. *corrugatus* (McCoy) in addition to the forms already given in my original account of the beds. This *Spirifer* bed forms a well-marked horizon along the top of the old quarries on both sides of Meathop Fell, and these two fossils are always found at this horizon in the district, together with the other characteristic species (given below). Mr. Jackson also states that he collected *Reticularia* aff. *lineata* (Martin) from this *Spirifer* bed. This statement, if corroborated, is decidedly important, as I have never found this species in the northern area below the horizon D 2–D 3. It is possible, however, that Mr. Jackson may be mistaken in his identification. Numerous examples of *Athyris glabistria* also occur at this horizon, and as the shells are badly preserved and often fragmentary an accurate determination is not always possible. My collections from the *Spirifer* bed at Meathop contain several other species not previously recorded, the majority of which also occur in the corresponding horizon in the Shap area. The following is a list of forms found in both localities, and shows the close parallelism of the deposits:—

Michelinia megastoma.
Camarophoria isorhyncha.
Syringothyris cuspidata.
Spirifer cf. *furcatus.*
Athyris glabistria.
Derbya sp.
Semimula gregaria, McCoy.
Productus cf. *corrugato-hemisphericus.*
P. cf. *pustulosus.*
Orthotetes crenistria (C 1 var.).
Examphalus.
Archæosigillaria Vanuxemi (Göppert).
Bellerophon sp.

In addition to these characteristic forms several interesting corals occur which are described in detail in my forthcoming paper.

The beds underlying the *Spirifer* bed at Meathop also contain forms which occur in a similar position below the *Isorhyncha* bed in the Shap area and confirm the correlation here given. It will be sufficient here to mention the occurrence in the lowest beds at Meathop of *Eumetria proava* (Phil.) and *Solenopora* sp., which I have found to characterize the lower portion of the C 1 horizon wherever these beds are exposed in the northern area.

With regard to the plant remains of Meathop, and elsewhere in Westmorland, they are the rule rather than the exception in these lower beds, and may occur at any horizon which happens to be locally near the base of Carboniferous formation wherever the beds were deposited in proximity to a subsiding land surface. Thus they occur near the local base at Meathop, Shap Abbey, Shap Toll Bar, Pinkskey Gill, Hebblethwaite Gill, near Horton-in-Ribblesdale and elsewhere.

Mr. Jackson suggests that *A. Vanuxemi* "may be helpful in arriving at a satisfactory conclusion as to the correct horizon" of the beds which contain it, and adds, "especially when the exact horizon

of the plant is known in the North Wales Exposure." I am afraid that I cannot agree with this suggestion; on the contrary I think that any conclusion, based on the occurrence of isolated fragments of plant-remains in the Lower Carboniferous rocks might be most misleading, and might result in serious errors in correlation.

Thus in the present instance *A. Vanuxemi* occurs at Meathop and at two horizons in the Shap district in beds which, as I have shown, belong to the C 1 horizon of the Bristol area, while in North Wales abundant remains of this species occur according to Messrs. Hind and Stobbs in S 2, an horizon very much higher in the series; lastly, this species was originally described from the Upper Devonian of New York. After all, this is only in keeping with what we have been led to expect from the study of the relative duration of terrigenous and marine floras and faunas elsewhere, for instance the Laramie and overlying formations in America.

NOTICES OF MEMOIRS.

Problems of the South-Western Highlands of Scotland. Abstract of the Presidential Address to the Glasgow Geological Society by Professor J. W. Gregory, D.Sc., F.R.S., F.G.S., January, 1910.

THE Southern Highlands of Scotland consist of a complex series of gneisses, schists, crystalline limestones and quartzites, trending across Scotland approximately from south-west to north-east. These metamorphic rocks are bounded abruptly to the south by the Highland Boundary Fault, which brings them against Upper Palæozoic rocks. Their northern boundary is less regular and is generally the junction with the Moine Gneiss, the rock which occupies so much of the Northern and Central Highlands. The schists and the associated rocks between the Moine Gneiss and the Boundary Fault may be conveniently grouped together, under the name proposed by Sir Archibald Geikie, as the Dalradian System.

The most important difficulty in the interpretation of these rocks is the uncertainty as to which is the upper and which the lower end of the succession. According to Nicol, the southern members are the youngest, and there is a descending series to the north. This view is contradicted by many obvious facts in the field geology; the view is therefore widely held that Nicol's order must be reversed and that the beds on the southern margin are the oldest. The serious difficulty in the second view is that the southern rocks are much less altered than the northern, and this theory therefore involves some measure of selective metamorphism. Several ingenious interpretations have been advanced to overcome this difficulty. The author of the address, however, held that both views as to the order of the succession are correct in parts.

The Dalradian System is intermediate in age between the Torridon Sandstone above and the Caledonian and Lewisian Gneisses below. That it is pre-Torridonian seems to follow from the evidence in Islay and Colonsay; that it is post-Caledonian is shown by its superposition upon the Moine Gneiss in several localities, as north of Ben Lui and in Glen Tilt; in the latter, the evidence collected by Mr. Barrow appears

conclusive that the Dalradians are resting on an eroded surface of the Moine Gneiss. The Dalradian System may be divided into five series as follows:—

Schiehallion Quartzite Series (including the Boulder Bed).
Blair Atholl Series (Limestones, black schists and quartzites).
Ben Lawers Series (Phyllites with some limestones and quartzites).
Loch Tay Series (Limestones, garnetiferous mica schists and some quartzites).
Loch Lomond Series (Gneiss, albite schist, etc.).

The most important rock in the lowest series is the Loch Lomond Gneiss, which is well developed in the peninsula of Cowal, on both sides of the northern part of Loch Lomond, and around Loch Katrine. This series consists mainly of coarse, highly inclined sedimentary gneiss and albite schists. This series extends eastward to Loch Voil, where it disappears beneath the rocks of the Loch Tay Series to the north and the overlap of the Ben Ledi and Ben Vane Grits and slates to the south. North of the Loch Lomond Gneiss occurs a series of garnetiferous mica schists associated with limestones and some quartzites. This series can be traced all across the country; it includes the Glen Daruel limestone south of Loch Fyne, and the limestones of Crianlarich, Glen Lyon, and Loch Tay. That they overlie the Loch Lomond Series is well shown north of Loch Voil, and that they rest unconformably on the Moine Gneiss is proved by the evidence north of Ben Lui. The essential member of the Ben Lawers Series is the phyllite of Ardrishaig, the Forest of Mamlorn and Ben Lawers. This phyllite is often intensely crumpled and seamed with innumerable thin quartz veins. It is associated with thin bands of quartzite and quartz-schist. Its superposition on the Loch Tay series appears to be clearly demonstrated from the relations of the two series at Ben Lawers, and still more clearly from the outliers of the Ben Lawers phyllite resting upon garnetiferous mica schists, as at Ben nam Imirean.

The Blair Atholl Series consists of the Blair Atholl Limestones, the black or graphitic schists and some interbedded quartzites, which are often of considerable thickness and form a large part of the Highland Quartzite. To separate them from the succeeding quartzite, it is proposed to call them the Cammock Hill Quartzite, from a locality where they are well exposed near Pitlochry.

The uppermost member of the Dalradian System is the Schiehallion Quartzite with the boulder bed at its base. It rests unconformably upon the Blair Atholl Series. Parts of the quartzite are quite unfoliated and remain as granular felspathic quartzites, in which the felspar grains have not been sheared or crushed.

According to this arrangement, the five series of the main Dalradian sequence occur in succession from south to north, and the oldest members are the most altered and highly crystalline.

Along the southern margin of the Dalradian schists there is a series of slates and grits, which are not foliated, and strikingly resemble ordinary Palæozoic slates and quartzites. The slates are worked at Luss and Aberfoil. The field relations of these Aberfoil Slates and

Ben Ledi Grits can be most easily explained by their unconformable deposition on the southern edge of the Dalradian rocks.

There has been assumed a transition from the Ben Ledi Grits to the intensely altered gneissic grits belonging to the Loch Lomond series, but the evidence for this passage is not convincing. The southernmost part of these comparatively unaltered rocks include cherts and shales which are marked on the Survey Maps as 'Silurian(?)'.[1] The exact age of these beds is doubtful. They may be Upper Dalradian and correspond to the great unconformity at the base of the Schichallion Quartzites, or, as is more probable, they may be post-Dalradian in age.

The relations of the Dalradian Schists is suggested as follows:—

Eozoic.	Algonkian . . .	Torridon Sandstone.
	Dalradian.	
	Caledonian . . .	Moine Gneiss and associated schists.
	Lewisian . . .	Fundamental Gneiss.

The classification suggested in the address adopts Nicol's succession in part, as it accepts the Aberfoil and Ben Ledi Series as younger than the Loch Lomond Gneiss against which they rest; and it is consistent with the less altered condition of the southern rocks and the steady diminution in the metamorphism of the rest of the series going northward, as for example, from the Loch Lomond Gneiss to the Loch Awe Grits, and from the garnetiferous mica schists of the Loch Tay Series to the black schists and unfoliated quartzites near Blair Atholl.

The evidence in some points of this succession is still incomplete, especially as regards some of the rocks nearest Glasgow. The special problems on which further research would be most useful were therefore mentioned, in the hope that the members of the Glasgow Geological Society would investigate them.

The subject is of interest from its bearing upon the early geological history and geography of North-Western Europe. The structure of Western Europe has been dominated by the formation of three great mountain systems, each due to pressure usually from the south, and each having its younger rocks exposed mainly on the northern flanks of the chain. The youngest is the Alpine System, formed mainly in Upper Cainozoic times, and including the Pyrenees, Alps, Carpathians, etc. A somewhat similar mountain system, of which fragments remain in Southern Ireland, Devonshire, Brittany and Germany had been formed in Upper Palæozoic times; from its analogy with the Altai Mountains of Asia, Suess has called its mountains the European Altaids. Still earlier, in later Archean times, there was formed the first of these European mountain systems, of which fragments occur in Northern Ireland, the Grampians, and Scandinavia. There are many interesting analogies between these old Grampians and the later Altaids and Alps. The old mountain system to which the Grampians belonged probably extended far westward into the North Atlantic and to its influence may be attributed the desert climate of Scotland during the deposition of the Torridon Sandstone.

[1] By kind permission of Dr. Horne it was announced during the address that Dr. Hinde has recently identified Radiolaria in the cherts of this series.

REVIEWS.

I.—Radioactivity and Geology: an Account of the Influence of Radioactive Energy on Terrestrial History. By J. Joly, M.A., Sc.D., F.R.S. 8vo; pp. xi + 287. London: A. Constable and Co., Ltd., 1909. Price *7s. 6d.*

THE developments which have followed so rapidly upon the discovery of the wonderful properties of radium have caused something like a revolution in more than one branch of physical science. How much these new developments concern geologists was first brought home to most of us by Professor Joly's address at the Dublin meeting of the British Association in 1908. The volume before us is an expansion of that address. In it the author marshals the results of researches, to which he has largely contributed, concerning the distribution of radium in igneous rocks, in sediments of different kinds, and in various waters. From the results thus brought together he deduces consequences of great moment, which are pursued, in successive chapters of the book, through all the ramifications of dynamic geology.

The variety of subjects which are passed in review, and the fact that they are presented as parts of an organic whole, make it difficult to do justice to Professor Joly's work in a brief notice. Indeed, it is scarcely possible to summarize what is in effect one extended chain of arguments resting on numerical data. It makes us see from a new point of view the complex interaction which unites the varied operations of inorganic nature. We are familiar, for instance, with the conception of a cycle of events: sedimentation leading to gradual subsidence of an area under the growing load, the heating of the depressed rock-masses causing upheaval and folding, finally erosion coming into play, with transportation and renewed sedimentation in an area adjacent to the former. Viewed in the light of the radium-content of the sediments, this assumes a new aspect. "The energy . . . is in fact transported with the sediments—the energy which determines the place of yielding and upheaval, and ordains that the mountain ranges shall stand around the continental borders. Sedimentation from this point of view is a convection of energy" (chap. v). In the following chapter the author endeavours to trace a like relation between the instability of the ocean floor and the radioactivity of oceanic deposits.

In a book treating of a field so wide and so little explored there is necessarily much which must be regarded as debatable. That the radioactive processes are not controlled by temperature or pressure is a thesis so remarkable that we are entitled to ask for very cogent evidence of it. Some experimental data bearing on this point are cited, but they do not apply to the breaking up of the parent uranium, upon which the whole train of transformations depends. If we can suppose this process to be checked by rise of temperature, Professor Joly's argument concerning the relation of underground temperature to radioactivity will require revision. It will be no longer necessary to assume that the heavy element uranium is accumulated in the outer layer of the globe, an arrangement which the author explains in a manner not very convincing.

Many readers will turn expectant to the chapter on "Uranium and the Age of the Earth"; but here we must confess some degree of disappointment. From comparative determinations of radium and helium, especially in phosphatic nodules,[1] Strutt has arrived at high estimates of the age of the stratified sequence. Since the most likely source of error is loss of part of the helium, these should be under- rather than over-estimates. Our author cites these and some other results, but only to emphasize the elements of doubt attaching to them. He then throws over radioactivity, and offers us, instead, two methods of calculating geological time which lead to very much lower figures. One is based on the rate of sedimentation, and the other on the amount of sodium in the sea. Both have already been before the geological public, and it is not necessary to enter into them. To us they appear far more hazardous than the helium method.

The manipulation of figures possesses an undoubted fascination. There is a feeling of security in striking a mean of discordant results, and a certain sense of generosity in allowing a margin on the side of safety; and it is easy for the enthusiastic speculator to forget how enormously errors may accumulate when several rough estimates are taken as links in a chain of argument. Even the taking of a mean demands more judgment than it sometimes receives. For instance, on p. 234 of this book, we are given the ratio of sediment carried in the waters of nine different rivers. This ratio ranges from 1 in 291 to 1 in 10,000. We do not believe that an average of nine figures so discordant can afford any useful information concerning the average amount of sediment carried by the rivers of the world. But, further, the author has taken a harmonic instead of an arithmetic mean. The true mean is not 1 in 2731, but 1 in 1182, which at one blow reduces the calculated eighty millions of years to about thirty-five millions! Personally we do not attach any weight to one or other of these figures.

We are far from wishing to disparage the introduction of quantitative considerations into dynamical and historical geology; but we feel at the same time the need for sounding a note of warning at the present juncture. Thanks to the discovery of radium, geology is finally delivered from the tyranny of a certain school of physicists, and Lord Kelvin's arguments based upon the *consistentior status* are swept away. Let us take heed lest, freed from one bondage, we fall straightway into another not less galling.

Probably Professor Joly does not look for unhesitating acceptance of all his conclusions. However much opinions may differ on some of the points raised, he has here introduced us to a large number of important and curious questions, and his book should be in the hands of every geologist who is interested in the modern developments of science.

A. H.

[1] Strongly confirmed, since this was written, by examination of zircons from igneous rocks of various ages.

II.—Geology in the Field. The Jubilee Volume of the Geologists' Association (1858–1908). Edited by H. W. Monckton and R. S. Herries. Part II: pp. 210–432, with 8 plates. London: Edward Stanford. 1910. Price 5*s.* net.

IN December last we drew attention to the publication of Part I of this work, and we are glad to note that a copious index is promised at the conclusion of the fourth part. The work is a more or less complex one, dealing sometimes with the geology of particular counties, at others with irregular districts, and again with particular formations in certain areas. The whole has been most carefully edited by Messrs. Monckton and Herries, whose task must have been no light one. The records of previous excursions made by the Geologists' Association form the basis of the work, and there are abundant references to the published proceedings, although the names of the responsible directors of excursions are not always indicated.

In the present part, "Berkshire and part of the Thames Valley" forms the subject of an article by Mr. H. J. Osborne White. He deals with strata from the Oxfordian to the Alluvial deposits. A useful sketch-map is given of the neighbourhood of Faringdon, showing the position of the pits in the famous sponge-gravel beds of the Lower Greensand.

"North Kent and adjoining parts of Surrey" are next described by Mr. A. L. Leach, who, after a brief reference to the Chalk, the Chislehurst Caves and Dene-holes, describes the principal sections in the Eocene strata, notes the Pliocene Beds of Lenham and elsewhere, and concludes with a short account of the superficial deposits and successive types of stone-implements.

"The Chalk Cliffs of Kent and Sussex and the Tertiary Beds of Herne Bay" are described by Mr. G. W. Young, with due references to the labours of Mr. Whitaker and Dr. Rowe, in whose footsteps Mr. Young has so successfully trodden.

"The Tertiary and Post-Tertiary Deposits of the Sussex Coast" are dealt with by Mr. J. V. Elsden. Newhaven, Bognor, and Selsey Bill come in for notice in connexion with the Eocene strata, while the Coombe Rock and other superficial deposits are discussed. The author remarks that the bottom of the Arun Valley is now considerably below sea-level.

"Hampshire and the Bagshot District" come into the appropriate hands of Mr. Monckton and Mr. Osborne White, who deal with the Chalk and Eocene, and especially with the Bagshot, Bracklesham, and Barton Beds.

"Wiltshire" is described by Mr. H. B. Woodward, who gives brief accounts of the famous sections in strata that range from Lias to Purbeck and Wealden, and from Lower Greensand to Chalk and Eocene, with superficial deposits of much interest. Reference is made to Mr. Harmer's 'Glacial Lake' in the Trowbridge Basin.

"The Palæozoic Rocks of Gloucestershire and Somerset" form the subject of an article by Professor S. H. Reynolds, who has added so much to our knowledge of the Tortworth Silurian area, and has discovered fossiliferous strata, probably of Llandovery age on the

Mendips. The associated volcanic rocks, the Old Red Sandstone and its fish-remains, and the zones in the Carboniferous Limestone Series are more particularly described, brief references only being made to the Coal-measures.

"The Neozoic Rocks of Gloucestershire and Somerset," including accounts of various formations from the Bunter to the Chalk and superficial deposits, are described by Mr. L. Richardson. As might be expected more details are given of the Rhætic Beds, with their basal grey marls, termed Sully Beds, that have yielded *Avicula* [*Pteria*] *contorta* and *Ostrea Bristowi*; of the Lias and Inferior Oolite and their 'hemeræ'. The geological history after the Cretaceous Period is briefly sketched, and full references are given to the literature of the Drift deposits.

"Dorset—Inland" is the title of an article contributed by the late W. H. Hudleston, and it is prefaced by a list of names of fossils and zones adopted by him, with remarks upon them, drawn up at his request, by Mr. S. S. Buckman. We must confess to a preference for the names used by Mr. Hudleston, whose judgment on these matters was always philosophic, sound, and practical. The principal sections in the Inferior Oolite near Sherborne and Yeovil are described; and an account is given of the Wareham District, with particulars of the well-boring at Bovington, and of the outlier of possibly Bembridge Limestone, discovered by the author at Creechbarrow Hill.

"The Dorset Coast" is described by Mr. Monckton, who deals with the strata visited during excursions made to Lyme Regis, Bridport, Weymouth, Abbotsbury, and the Isle of Purbeck.

"The Isle of Wight" is dealt with by Mr. Herries, who has given a concise account of the physical features and geology of this oft-visited geological paradise.

There is therefore plenty of interesting and instructive material to be found in this part of "Geology in the Field", and it will be of essential service to all who visit the districts described.

III.—A Treatise on Zoology. Edited by Sir Ray Lankester, K.C.B., M.A., LL.D., F.R.S. Part IX: Vertebrata Craniata (First fascicle: Cyclostomes and Fishes), by E. S. Goodrich, M.A., F.R.S. London: Adam & Charles Black, 1909. 8vo; pp. xvi+518, with 515 text figures. Price 15*s*.

THIS volume, like the others of the series to which it belongs, is devoted to morphology and classification; it contains valuable and well-written accounts of the general characters of the Craniate Vertebrates, of the Cyclostomata and Gnathostomata, of the Fishes, and of the two main branches of the last-named, the Chondrichthyes and Osteichthyes; the results of Mr. Goodrich's recent important researches on the exoskeletal structures of fishes and on the origin of limbs are here included.

The morphological parts of the book suffer a little from compression, and from the paucity of references to function. The statement that the jaws developed from the first pair of visceral arches might have been qualified, for the labial cartilages may reasonably be interpreted as the remnants of præ-mandibular arches.

The arrangement of the Selachians (*Chondrichthyes*) differs from most recent systems in the recognition of only four primary groups, the Holocephali and Euselachii (Selachii of Goodrich) being united to form a division co-ordinate with the Ichthyotomi, Pleuropterygii, and Acanthodii. In a natural system the two last-named should be placed first, the structure of their paired fins and the absence of mixopterygia indicating their generalization: of the other three orders, or sub-classes, characterized by the presence of mixopterygia, the Holocephali are quite as distinct from the Euselachii as from the Ichthyotomi; the presence of a pharyngo-hyal shows that their autostyly is not a modified hyostyly, and Mr. Goodrich has failed to recognize that in the Selachians the terms 'hyomandibular' and 'epihyal' are synonymous, and that the hyoid arch of the Chimæroids is essentially similar to the succeeding branchial arches.

The classification of the modern Sharks and Rays is marred by some erroneous diagnoses and unnatural groupings; for example, the Lamnidæ are said to have no oro-nasal grooves, wide gill-openings, a pit at the base of the caudal fin and a keel on each side of the tail, and they are made to include *Alopias*, which has small gill-openings and no caudal keel, the Odontaspidæ, without or with vestigial pit and without keel, and *Rhinodon*, which differs from them *in toto* in the presence of oro-nasal grooves, the position of the gill-openings above the pectoral fin, etc., and indeed belongs to the Orectolobidæ, which family our author unites with the very different Scyliorhinidæ (Scylliidæ).

The Chondrichthyes are followed by the Ostracodermi, a provisional group; here some of Dr. Traquair's recent interesting discoveries from the Silurian of Scotland are described and figured, and his views as to the relationship of the Cœlolepidæ, Psammosteidæ and Drepanaspidæ are confirmed by Mr. Goodrich's demonstration of the structural similarity of their exoskeleton. A new restoration of *Cephalaspis* calls for comment, as the organs shown by Dr. Smith Woodward to be 'opercular' prolongations of the head-shield, are figured and described as scaly, fin-like lobes, narrowed at the base, and projecting from each side of the body behind the head-shield; we venture to think that there is no justification for this interpretation.

The Osteichthyes are divided into two main branches, the Dipnoi (with which the Arthrodires are provisionally associated), and the Teleostomi; it is not a little singular that this arrangement should be maintained by Mr. Goodrich, whose embryological researches have confirmed the secondary nature of the so-called 'archipterygium', and who first described the similar structure of the Osteolepid and primitive Dipnoan scales and fin-rays, and the nearly normal arrangement of the bones of the cranial roof in Dipnoan genera such as *Phaneropleuron* and *Ctenodus*.

The Dipnoi indeed scarcely differ from the Osteolepida except in their autostyly, and as this is plainly a modified hyostyly, from the structure of the hyoid arch, they should follow that group in a natural system. The modern Dipnoans are said to have internal nares, but as a matter of fact the nostrils are merely labial, as in some Eels (*Ophichthys*), and the posterior ones cannot be homologized with true

internal nares. Mr. Goodrich thinks that the nostrils were ventral in the Osteolepida; this can scarcely have been the case in fishes with a terminal mouth and marginal dentition, and in which (as in *Cricodus*) the small nasal pits were antero-lateral.

The Crossopterygii follow the Dipnoi, and lead through *Polypterus* to the Chondrostei; the highly specialized present-day members of the last-named group still retain many features of generalization, notably in the paired fins, and they can be traced back step by step to the palæozoic Palæoniscidæ, in our opinion the most primitive of all Teleostomes, in which the pelvic fins had an extended base, and were supported, as in the modern *Psephurus*, by a series of parallel pterygiophores. Mr. Goodrich has shown that *Polypterus* agrees with the Palæoniscidæ in scale structure, and this confirms the evidence derived from the paired fins, that the recent genus is not descended from the Osteolepida, but from more generalized Crossopterygians.

In the classification of the Mesozoic fishes of the Actinopterygian series Mr. Goodrich follows Dr. Smith Woodward, except that he makes the Amioids equivalent in rank to the Teleosts, and by placing the Oligopleuridæ and some allied families in the former renders neither group definable. The classification of the Teleosteans is based on that of the "Cambridge Natural History", but the best feature of that system, its simplicity, has been lost. A number of new, and often unnatural, divisions are established, many of which are merely designated Super-family I, Branch A, Sub-tribe B, etc., and when names are given they only confuse matters still more. Thus the Cypriniformes are a sub-order, the Lampridiformes a division, the Zeorhombiformes a subdivision, the Perciformes a tribe, and the Chætodontiformes a sub-tribe, whilst the termination *oidei* is also used for a number of groups of unequal rank. In addition to the Siganidæ (Teuthididæ of Günther) and the Acanthuridæ (Teuthididæ of modern authors) a family Teuthididæ is included and diagnosed which has no actual existence. The interposition of the Plectognathi between closely related families such as the Serranidæ and Centrarchidæ, and of the Ostariophysi between the Leptolepidæ and Elopidæ, cannot easily be justified; it would be paralleled by the intercalation of the Marsupials between *Ornithorhynchus* and *Echidna*.

The illustrations are numerous and on the whole well-executed. Mr. Goodrich's original restorations of the crania of some extinct Dipnoans, and his diagrammatic sections illustrating scale structures are especially interesting. One of the least satisfactory figures is that of the caudal fin of the cod, for it does not show that most of the rays, except the few attached to the reduced hypural, are inserted each on its own basal support; the latter are about twice as numerous as the neural and hæmal spines, with which about half of them are ankylosed, whilst the rest remain distinct or unite with the neural and hæmal spines by suture. This structure, clearly seen in *Gadus virens* and *G. morrhua*, is probably characteristic of all the Gadidæ.

A useful bibliography concludes the book, which, on the whole, does not compare favourably with some of the others in this series; for whilst the general chapters reach the high level expected of

a zoologist of Mr. Goodrich's reputation and experience, the systematic portions, in the case of some of the recent groups, indicate that he is not thoroughly acquainted with the animals about which he is writing.

C. T. R.

IV.—British Fossils. Monographs of the Palæontographical Society,[1] 1909, vol. lxiii.

THE beautifully illustrated works on British fossils published by the Palæontographical Society still appear with their wonted regularity. There is no lack of valuable material, and palæontologists who have opportunity for pursuing extended researches are glad to avail themselves of the facilities for the adequate illustration of their writings afforded by the Society. It is only to be regretted that the annual volume shows a tendency to reduction in size, owing to the recent death of numerous old subscribers and the tardiness of the new generation in taking their places.

The volume for 1909 opens with another instalment of the Monograph of British Pleistocene Mammalia by Professor S. H. Reynolds. This year he deals with the Canidæ, and publishes a fine series of illustrations of the skulls and teeth of the wolf, Arctic fox, and common fox. The text is disappointing and scarcely does justice to the subject; but the measurements and drawings will be very useful to collectors for identification of their specimens. Dr. A. S. Woodward follows with the fifth part of his Fossil Fishes of the English Chalk, treating of the Ganoids (except *Protosphyræna* and *Belonostomus*, which were described in the previous year). Some of the remains are very fragmentary and hardly worth description; but the unique collection of *Macropoma* from the English Chalk has afforded the opportunity for a valuable new contribution to our knowledge of the Cœlacanthidæ. A drawing of the restored skeleton of *Macropoma*, by Miss G. M. Woodward, is included. Dr. Traquair contributes another instalment of his important memoir on the Carboniferous Palæoniscid Fishes, with a fine series of plates. He writes chiefly of *Acrolepis* and *Nematoptychius*, and adds drawings of *Rhadinichthys*, which are presumably to be described in the next part. *Acrolepis Hopkinsi* appears to occur above and below the Millstone Grit—an unusually extended distribution. Mr. Henry Woods provides the largest section of the volume in another part of his well-known Monograph of Cretaceous Lamellibranchia, which makes excellent progress. This year he deals with the Solenidæ, Saxicavidæ, Pholadidæ, Teredinidæ, Anatinidæ, Pholadomyidæ, Pleuromyidæ, Poromyacidæ, and Cuspidariidæ. It is a most laborious work, on account of the extensive literature which has to be digested while the fossils are studied; but it is evidently done with thoroughness. The volume concludes with title-pages and indexes for Sharp's Mollusca of the Chalk and Phillips' British Belemnites, which were left unfinished by the death of the authors many years ago.

[1] Annual subscription, which entitles to membership, £1 1*s*., due January 1. Apply to the Secretary, Dr. A. S. Woodward, F.R.S., British Museum (Nat. Hist.).

V.—Brief Notices.

1. Soils of South Africa.—Dr. C. F. Juritz, in his Presidential Address to Section 2 of the South African Association for the Advancement of Science, on September 29, 1909, has some pertinent remarks on this subject. After sketching the general lines of soil investigation, he states: "We have not been able to do all this in the Cape Colony, because the entire work of investigating the Colony's soils has always been allocated to one solitary man, and even then it has been subject to constant interruption." He proceeds to point out what is done in the United States, and shows that the original staff of 10 men (not one man) had, ten years after its establishment, increased to 127 men, including 83 scientists and soil experts, 13 tobacco experts, and 29 clerks and other employés, and still was found inadequate for one-half the demands made upon it for investigations along its special lines. Dr. Juritz, quoting the official publications, points out that extraordinary increases in land value have followed the work of the Bureau of Soils in the United States. Soils in the Connecticut Valley, which the Bureau showed were adapted for growing a superior tobacco, increased in value threefold. Trucking soils of the Atlantic seaboard have risen from 5 dollars an acre to 200 dollars; rice lands of Louisiana from 5 to 50 dollars; and Florida patches, specially adapted for growing pine-apples, from nothing to over 500 dollars an acre. Upon these facts and many others Dr. Juritz comments: "Has not the time arrived for this important subject to be tackled in right earnest in our own South Africa instead of continuing merely to be toyed with?"

2. Soils of Hungary.—For many years the study of the soils of Hungary has occupied a number of her best investigators, and in February last year the Royal Hungarian Geological Institute (*Magyar kiralyi Földtani Intézet*) issued invitations for a Conference of Agrogeologists to meet in Budapest. This was, we believe, the first Agrogeological Congress, and the report of its deliberations is now before us as *Comptes Rendus de la première Conférence Internationale Agrogéologique*. The volume consists of 334 pages and has a soil map of Roumania with an inset map of the climatic zones of the same country. Sixty-nine pages are devoted to the reports of the meetings of the Congress, twenty to the excursions made to Hidegkut, Gödöllo, the Great Plain (Alföld), and to Lake Balaton; and the remainder of the volume is occupied by papers on various subjects as follows:—Soils of European and Asiatic Russia, by Glinka; Soils of Norway, by Björlykke; Daily Weathering in the light of Colloidal Chemistry, by Cornu; What is Weathering? by Treitz; Climatic Zones of Soils, by Cholnoky; Special Exigences of Agriculture with regard to Analyses of Soils, by Leplae; Methods of Soil Analysis in the Prussian Survey, by Schucht; Agrogeological Maps, by Timko and Güll; Agronomical Work in Bohemia, by Kopecky; Chemical Analyses of Soils, by Emszt and Sigmond; The Körös Floods, by Ujj; Soda-holding Soils, by Sigmond; Ampelogeological Maps, by Dicenty; Lime-holding Soils, by Treitz; Mineral Soils, by Atterberg; Unification of Methods of Chemical Soil Analyses, by Hilgard; and the Soils of Roumania, by Murgoci.

3. The Wakatipu District, New Zealand.—Professor James Park, in his Presidential Address to the Otago Institute, 1909, on the origin and history of the Wakatipu District, deduced from the facts observed by him in the course of his survey that probably in the Pleistocene Period the southern portion of the South Island of New Zealand had been covered by an ice-sheet, some 7500 feet in thickness. That is to say, there has been an Ice Age in New Zealand similar to that in the Northern Hemisphere.

4. The Temperature of the Earth and Earth-movements.—The Government of New Zealand has placed £200 at the disposal of the Philosophical Institute of Canterbury, New Zealand, to enable that body to investigate the temperature of the earth's crust and other geophysical and geological phenomena rendered possible by the construction of the Arthur's Pass Tunnel. It is further announced in the Proceedings of the New Zealand Institute that the Government are taking practical steps to erect bench-marks at suitable places along the coast.

5. The Tertiary Beds of North-West Germany.—Dr. A. v. Koenen has brought together the latest information on the Tertiary of North-West Germany originally investigated by Beyrich fifty years ago. His pamphlet (*2 Jahresber. Niedersächsischen geol. Ver. zu Hannover*, 1909) sketches the Palæocene, the Oligocene, and the Miocene, and gives a list of fossils from Volpriehausen, with annotations as to similar occurrences in the Scaldisian and the English Crag.

6. The Geology of the Waterberg Tin-fields, by H. Kynaston, E. T. Mellor, and U. P. Swinburne, forms No. 4 of the Geological Survey Memoirs of the Transvaal Mines Department, 1909. The ore occurs as Cassiterite. The geological structure of the country is comparatively simple. The central plateau is formed of the Upper Sandstones of the Waterberg system and the outer rim by the high ranges of granite and felsite which form the watershed between the Stark River and the Nyl and Magalakwin. Excellent coloured maps and sections accompany the paper.

7. The Copper, Tin, and Silver Deposits of Pitkäranta on Lake Ladoga form the subject of the *Bulletin de la Commission Géologique de Finlande*, No. 19 (November, 1907). The report is written by Otto Trüstedt, and occupies 334 pages. Many figures of rock-structure are given, and several plates are devoted to illustrating "Eozoon-Serpentine Zones". There is a coloured map, a table showing the output of the mines since 1814, and a list of all minerals recorded.

8. The Miocene of Astoria and Coos Bay, Oregon (U.S. Geol. Surv., Prof. Paper 59, 1909).—Dr. W. H. Dall has reprinted twelve papers by previous authors on the same subject because of their inaccessibility to students living in the Pacific States. Happy students! And generous Government! The work itself is produced in Dr. Dall's customary careful style, and is well illustrated by twenty-two plates of fossils, text-figures, and map. Many new forms are described, the validity of several genera is discussed in detail, and a further description of the fossil sea-lion (*Pontolis magnus*), by F. W. True, is appended, and illustrations of its skull are given.

9. The Gotlandian of Fyledal.—Professors J. E. Moberg and K. A. Grönwall have contributed to *Meddelande från Lunds Geologiska Fältklubb* (ser. B, No. 3, 1909) a paper on the Gotlandian of Fyledal. The beds are rich in the genus *Bellerophon*, and contain numerous ostracoda of a familiar type to those who work in similar English deposits. Thus of nineteen forms described seven or eight are identical with those recorded from the Upper Silurian of England by Jones and others.

10. New Zealand Geological Survey.—From the geology of the Whangaroa subdivision, Hokianga division, by J. M. Bell and E. de C. Clarke (Bull. N.Z. Geol. Surv., No. 8, 1909) we learn that the beds exposed in their area are pre-Cretaceous, late Mesozoic, Eocene, Miocene, and recent, with much intrusive and other igneous rock of doubtful age. Fossils are found of Cretaceous age, but they are imperfectly preserved and difficult to clean owing to the hardness of the matrix. They include *Trigonia*, *Desmoceras*, *Hamites*, *Ostrea*, and *Oxyrhina*, and these are said to be insufficient, even with other fragmentary remains, to allow of correlation with the other New Zealand Mesozoic beds. The igneous series are described in much detail, and numerous micro-sections of the rocks are given. The economic geology includes notes on cupriferous sulphides, mercury ores, precious metals, iron, manganese oxides, kauri-gum, oil, building and cement stones, mineral waters, and sulphur. A list of minerals met with, and a glossary of scientific and mining terms used in the report, are appended.

11. A Fossil Horse in South Africa.—Dr. R. Broom, among several Reptilian papers in the Annals of the South African Museum (vol. vii, pt. iii, April, 1909), calls attention to the evidence in favour of the existence of an extinct horse in South Africa. Three specimens have now been found, and the last "makes it pretty certain that a very large horse was a native of South Africa before European occupation". In a slab of the coast-limestone cast ashore at Yzerplaatz is the greater part of the lower jaw of a large horse. This he now calls *Equus capensis*. The third premolar shows no trace of the rudimentary protostylid as compared with that of the modern horse. Teeth of a horse were described by Fraas from South Africa in 1908, and on May 11, 1909, Professor Ridgeway showed a portion of the fossil jaw of one of the Equidæ from Naivastra, German East Africa, to the Zoological Society of London.

12. Fossil Vertebrates of the Karroo, South Africa.—In the same number of the Annals of the South African Museum, Dr. Broom makes an attempt to determine the horizons of the fossil vertebrates of the Karroo. In drawing up the table he has ignored types founded on vertebræ or fragments of skeletons, as most of these are probably portions of animals already known from their skulls.

13. Distribution of Iron Ores in Egypt.—Dr. Fraser Hume discusses the Distribution of Iron Ores in Egypt, in Survey Department Paper No. 20 (Ministry of Finance, Egypt, 1909). Southern Sinai, the N.E. and S.E. deserts, the oases, the ferruginous beds in the Nubian

Sandstone, Sudan, Darfur, Kordofan, and Abyssinia are all referred to, and a map is given showing the distribution. The iron of Egypt does not appear to be of much commercial importance, but that of Darfur and Kordofan may possibly be worth attention in future.

14. Cretaceous of Pondoland. — With regard to the age of the Cretaceous rocks of Pondoland and those of Port Durnford to beyond St. Lucia Bay, it has been shown by Mr. Henry Woods (Ann. South African Mus., iv (7), December, 1906) that they are the equivalent of the Campanian (Upper Senonian) of Europe, the Ariyalur Beds of Trichinopoli, and the Valudayur and Trigonoarca Beds of Pondicherri. Deposits of a similar age have been shown to occur in Madagascar. Griesbach supposed that five faunas could be recognized in successive zones of these African deposits, and correlated the uppermost with the Greensands and the White Chalk of England. Later on, Rogers and Schwarz showed that the fauna was more generally distributed vertically than Griesbach had supposed, and belonged to one deposit. Woods' work confirms this, and proves that only one zone is represented.

15. The Phosphate Deposits of South Carolina and New Brunswick. By G. F. Matthew, LL.D., F.R.S.C. Bull. Nat. Hist. Society of New Brunswick, vol. vi, pt. ii, p. 121.—This is a brief account of a visit to the deposits on the rivers of South Carolina, from which so much calcium-phosphate has been obtained of late years, chiefly in the form of bones and teeth of extinct forms of vertebrates taken from layers under the river beds of those streams. The remains are of various ages, from the Eocene upwards, but have been rolled in the sea and redeposited in beds, which contain many recent shells and so are comparatively modern. These recent deposits are compared with the vastly more ancient Cambrian phosphates of New Brunswick, which have been accumulated under somewhat similar conditions. In these last-named beds the phosphatic nodules are mingled with Brachiopod shells and the detached portions of the heads and body-segments of trilobites.

16. Geological Time.—In an article on "The Accumulation of Helium in Geological Time" (Proc. Roy. Soc., 1909, ser. A, vol. lxxxiii, p. 96) the Hon. R. J. Strutt gives the results of investigations among iron-stones which contain helium. He remarks that the results on hæmatite from co. Antrim are especially noteworthy, as it would appear that the Eocene period must be put back thirty million years.

17. Royal Scottish Museum, Edinburgh.—A useful *Introduction to Petrography and Guide to the Collection of Rocks* in the museum has been prepared by Dr. S. J. Shand (pp. 50, 1909), and is sold at the price of one penny. It deals with the Igneous, Sedimentary, and Metamorphic rocks, and contains introductory remarks on the nature and genesis of rocks, and on the general character of minerals. Moreover, it has a good index.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

January 12, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Igneous and Associated Sedimentary Rocks of the Glensaul District (County Galway)." By Charles Irving Gardiner, M.A., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S.; with a Palæontological Appendix by Frederick Richard Cowper Reed, M.A., F.G.S.

The general succession of the rocks of the Glensaul district is as follows, in descending order:—

3. ? Bala Beds. Conglomerates and Sandstones.
These beds have not been studied.

2. Shangort and Tourmakeady Beds.	*Thickness in feet.*
(8) Calcareous gritty tuff of no great coarseness, sometimes becoming so calcareous as to pass into fairly pure limestone, enclosing also bands and patches of limestone breccia, and, more rarely, bands of highly fossiliferous limestone which in some cases has been shattered by earth-movements.	
(7) Very coarse tuff or breccia, mainly composed of felsite fragments: associated with it are impersistent bands of fine tuff . .	750
(6) Tuff, coarse and fine, with occasional patches of calcareous beds, and at one point graptolitic beds indicating the zone of *Didymograptus hirundo*	150
(5) Great felsite sill of Tonaglanna and Greenaun . . about	1100
(4) Coarse grit	20
(3) Gritty tuff . . . . . varying in thickness from	520 to 620
(2) Coarse tuff or breccia, mainly composed of felsite fragments .	75
(1) Fine banded tuff	55
1. Mount Partry Beds.	
(4) Coarse grits	150
(3) Fine grits and tuffs associated with black chert, graptolitic beds, and a prominent band of coarse tuff or breccia about 30 feet thick. The graptolites indicate the zone of *Didymograptus extensus* . . . . . (?)	150
(2) Coarse grits	110
(1) Coarse conglomerates, about 600 feet seen.	

The graptolitic beds occurring in Band 3 of the Mount Partry Beds have yielded nineteen species, which have been determined by Miss G. L. Elles, D.Sc., who considers that they indicate the upper part of the zone of *Didymograptus extensus*. The commonest species met with are *D. extensus*, Hall, and *D. bifidus*, Hall, both species being represented by small mutations. Rounded bodies, which a comparison with the better preserved specimens from the Tourmakeady district shows to be almost certainly Radiolaria, were noted in sections of the cherts and shaly beds at several points.

In a previous description of the rocks of the Tourmakeady district, the term Shangort Beds was applied to a series of grits and tuffs, and the term Tourmakeady Beds to an associated series of calcareous strata which generally take the form of limestone breccias. In the

Glensaul district it is not possible to draw a sharp line of distinction between the two rock-types, some of the calcareous gritty tuffs passing into nearly pure limestone; but the authors retain the terms to indicate the close connexion between the two districts.

The fossils from the Shangort and Tourmakeady Beds, which have been examined by Mr. F. R. Cowper Reed, show a close resemblance to those of the Tourmakeady district; but the finding of certain additional forms, especially *Nileus armadillo* and *Niobe* sp., has impressed upon Mr. Reed the close connexion between this fauna and that of the *Orthoceras* Limestone of Sweden, and has convinced him that it is rather of Arenig than of Llandeilo age. The conclusion is in conformity with the field-evidence, for at one point beds of gritty shale, containing Radiolaria and Graptolites (indicating the zone of *Didymograptus hirundo*), occur associated with the tuff of the Shangort Beds. The relegation of the Shangort and Tourmakeady Beds of Glensaul to the Arenig would imply a similar age for those of the Tourmakeady district.

The Glensaul district contrasts strongly with that of Tourmakeady as regards the character of the crystalline igneous rocks, which are all quartz-felsites, and the authors believe them to be entirely intrusive.

Mr. F. R. C. Reed describes one species of *Illaenus*, one of *Niobe*, one of *Nileus*, two of *Bathyurus*, three of *Cheirurus*, one of *Pliomera*, one of *Encrinurus*, one of *Phacops*, and a new species of *Bathyurellus*. He also describes three species of *Orthis*, one of *Hyalithes*, one of *Rafinesquina*, one of *Camerella*, and one of *Porambonites*, and his conclusions as to the evidence which is furnished by the fauna regarding the age of the beds are mentioned above.

2. "On the Gneisses and Altered Dacites of the Dandenong District (Victoria), and their Relations to the Dacites and to the Granodiorites of the Area." By Professor Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S.

The area described lies about 25 miles south-south-east of Melbourne. The earlier literature is discussed, and it is shown that the early geological surveyors regarded the dacites as Palæozoic 'traps' passing gradually into the granodiorites. Professor J. W. Gregory first described the rocks as dacites, probably of Lower Tertiary age, resting upon the denuded surface of the granodiorites and of the adjoining Lower Palæozoic sediments. The author describes the field-relations of the rocks, and shows that gneiss occurs between the dacite and the granodiorite in places. Elsewhere at the contact the dacite appears slightly altered. The contact with the plutonic rock is everywhere abrupt. No foliation or banding occurs in the granodiorites, but acid veins pass from the junction into the altered dacite and also cut across the foliations of the gneiss. The field evidence, therefore, shows that the dacites are older than the granodiorites, and also that the gneiss was formed before the intrusion of the acid veins. Chemical analyses of the rocks and of the coloured minerals of the dacites are recorded.

The chemical evidence indicates that slight differentiation of a magma took place: the dacite was first erupted, and, following

shortly on that, the granodiorite (of slightly more acid composition) was intruded into the dacite. The microscopic characters of the granodiorite, the dacite, the altered dacites, and the gneiss are described. In the altered dacites a slight banding or schistosity occurs near the contact, ilmenite is changed to secondary biotite by reaction with the felspar in the microgranular groundmass, biotite is corroded by the attack of the groundmass, and hypersthene is altered at its margin to secondary biotite and secondary quartz. Finally, minute granules of blue tourmaline occur in the contact rocks. All the changes enumerated above are attributed to contact-metamorphism caused by the intrusion of the granodiorite.

In the gneiss, hypersthene is not found, ilmenite is rare, and the rock is completely foliated. It shows a granular groundmass similar to, but coarser in grain than, the groundmass of the dacite. Besides occurring at the contact, it has also been found in parallel zones intercalated in dacite near the contact.

The author believes that the gneiss is a peculiar modification of the dacite, but direct evidence as to its mode of origin is as yet incomplete. It may possibly be the result of extreme contact-metamorphism of a dacite of peculiar character, such as a tuff. It is possible that it was produced by differential movement in the dacite before complete consolidation, and certainly before the intrusion of the granodiorite. Since, however, dynamic effects are present in some sections, and are accompanied by changes found in the dacites altered by contact-metamorphism, the author is rather inclined to support the view that primarily the gneiss is due to differential movements in part of the dacite series, complicated by effects due to contact-metamorphism by the later intrusion of the granodiorite.

3. "Recent Improvements in Rock-Section Cutting Apparatus." By H. J. Grayson, Demonstrator of Petrology and Assistant in the Geological Department, University of Melbourne. (Communicated by Professor E. W. Skeats, D.Sc., A.R.C.S., F.G.S.)

The apparatus described has been designed and constructed by the author, for use in the University of Melbourne. It comprises a slitting disk of mild steel and two bronze grinding laps, mounted on a very substantial wooden table. The disks and laps are each 10 inches in diameter, and revolve at about 900 revolutions a minute. The disks and laps are connected with endless belts, which in turn are connected with wheels driven by a 1 horse-power electric motor. Special clamps are used to attach the rock-specimen and to cut the slice. A goniometric crystal-holder, permitting of slicing in any desired direction, is described, and can be fitted to one of the clamps. Clamps swinging radially across the grinding laps permit the parallel grinding of the slice to any required thinness. A polishing lap can be placed in the position of one of the grinding laps. The finishing of the slice is done by hand on a slate disk. In the second part of the paper the author describes in detail the method which he employs in making a rock-section, and refers to a number of improved methods or variations of the usual processes which he has in practice found advantageous.

January 26, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "On a Skull of *Megalosaurus* from the Great Oolite of Minchinhampton." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., Sec. G.S.

The specimen was discovered and prepared by Mr. F. Lewis Bradley, F.G.S., and shows for the first time the skull of *Megalosaurus*. It agrees closely with the Megalosaurian skulls of other genera already discovered in the Jurassic and Cretaceous of North America, and resembles *Ceratosaurus* in possessing a bony horn-core on the nose. As in the jaws of *Megalosaurus* previously known, the premaxilla of the new specimen bears four teeth: but these teeth are so different from those of the typical *M. bucklandi* of the same horizon that they prove the Minchinhampton fossil to belong to a distinct species.

2. "Problems of Ore-Deposition in the Lead and Zinc Veins of Great Britain." By Alexander Moncrieff Finlayson, M.Sc., F.G.S.

Chemical analyses show traces of lead and zinc in several of the rock-formations of Britain, but the ores of the veins are concluded to be derived, not from the country rock, but from deeper sources, probably in the first place by magmatic segregation. They were transported in the deeper zones by 'juvenile' waters, in which fluorine was an important constituent, while in the upper zones, especially in limestone districts, underground waters of meteoric origin have played a large part. The vein-solutions carried (1) alkaline sulphides, which held the sulphides of the metals in solution, and (2) alkaline and earthy carbonates. The presence of the latter is indicated by the alteration of the wall-rock, which shows a concentration of potash, lime, and carbon dioxide, and a leaching of soda, magnesia, oxides of iron, and silica. In limestones, however, the chief effects of solution on wall-rock were concentration of silica and magnesia.

The filling of fissures rather than direct replacement of rocks by ores has been the chief process, but the calcium of fluorspar has been very largely derived from the country rock. Further, much local metasomatism is seen, such as replacement of limestone by fluorspar, galena, blende, and quartz; and replacement of fluorspar by galena.

The order of deposition determined by microscopic examination of polished specimens of ores has been: chalcopyrite, fluorspar, blende, galena. The galena carries its silver generally in molecular or isomorphous combination, except in the case of rich ores, when native silver and argentite appear sometimes as threads along the cleavage-planes.

In the effect of the country rock on ore-deposition, the chief factors have been: (1) the physical character of the rock and the consequent nature of the fissure, (2) its porosity, and (3) its chemical composition. The process of deposition involves interchange of constituents between rock and solutions, even with the least soluble rocks.

Ore-deposition has persisted over a vertical range of 5000 to 6000 feet, of which over one-half has been shorn off by denudation. The effects of secondary processes have been exerted to depths of over 600 feet. The main points in the work are supported by field-observations, and by the results of microscopic and chemical research.

3. "The Vertebrate Fauna found in the Cave-Earth at Dog Holes, Warton Crag (Lancashire)." By John Wilfrid Jackson, F.G.S., Assistant Keeper in the Manchester Museum.

The remains described in this communication were obtained during the systematic investigation by the author of a cave on Warton Crag (West Lancashire) in 1909.

The cave, known as Dog Holes, is situated on the western side of Warton Crag, and opens on a sloping 'pavement' of limestone. It owes its origin to the erosion of a series of master-joints in the Carboniferous Limestone.

The present entrance to the cave is by a vertical drop from the general level of the 'pavement'. This entrance is undoubtedly of secondary origin, and is due to the falling-in of the weakened roof of one of the passages.

The specimens were derived from the cave-earth below the surface-soil in one of the chambers of the cave. They comprise a large series of small vertebrates, including Rodents, Insectivores, Amphibians, Birds, etc. Among the Rodents are some interesting forms, the chief of which are the Arctic and Norwegian Lemmings and the Northern Vole.

A large series of non-marine Mollusca was found along with these remains, one species being of particular interest, namely *Pyramidula ruderata*, only known in this country by its fossil remains in Pleistocene deposits.

The Pleistocene age of the remains is fully discussed, as well as their possible mode of origin through a former swallow-hole.

In many respects the cave and its contents bear a striking resemblance to the famous Ightham Fissures.

February 9, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

Dr. Douglas Mawson, B.Sc., B.E., Lecturer in Mineralogy in the University of Adelaide (South Australia), delivered a lecture entitled "With Sir Ernest Shackleton in the Antarctic", illustrated by lantern-slides.

The President proposed and Sir Archibald Geikie seconded a vote of thanks to the Lecturer, which was adopted with acclamation and suitably acknowledged.

II.—Mineralogical Society.

January 25.—Professor W. J. Lewis, F.R.S., President, in the Chair.

Dr. S. J. Shand: On a group of minerals formed by the combustion of pyritous shales in Midlothian. At the Emily Coal-pit, Arniston, as the result of the slow combustion of a heap of shaly refuse, which became spontaneously ignited, presumably owing to the evolution of

heat caused by the atmospheric oxidation of pyrites, a number of uncommon mineral species have been formed, of which five have been recognized, viz. native sulphur, sal-ammoniac, tschermigite, mascagnite, and a possibly new species, aluminium sulphate.—Professor W. J. Lewis: A Crystal-holder for measuring large specimens. For this purpose a clamp of convenient form and with various adjustments has been designed and made by Mr. Pye.—Mr. T. Crook: Some observations on Pleochroism. The phenomena of pleochroism displayed by plates of coloured minerals when examined in ordinary light were treated in a general way for both parallel and convergent rays, and the factors upon which they depend were discussed.—Mr. L. J. Spencer: Notes on the Weight of the 'Cullinan' Diamond, and on the Value of the Carat-weight. Varying statements of the weight of the 'Cullinan' diamond, in its original, uncut form have been published, but from a comparison of the carat-weights against which it was weighed in 1905 it is concluded that the correct weight was 621·2 grams, or 3025$\frac{3}{4}$ English carats of about 205·304 milligrams (as defined by the Standards Department of the Board of Trade in 1889). Other values are, however, given for the English carat and for the carat in other countries, and the average value has decreased on the whole in course of time. The carat-weight had its origin in the use as weights of seeds of *Ceratonia siliqua*, which weigh approximately a carat. The existing confusion would be obviated by the general adoption of the metric carat of 200 milligrams (one-fifth of a gram) recently recommended by the International Committee of Weights and Measures (*Nature*, 1908, vol. lxxii, p. 611).—Dr. G. T. Prior: On a Basalt from Rathjordan, Co. Limerick. Specimens of basalt from Rathjordan in the Allport Collection in the British Museum show in thin slices under the microscope round sections of isotropic material containing central and marginal inclusions, and thus resembling small leucites. The rock is very similar, mineralogically and chemically, to leucite-basalts from Bohemia, but contains only a small fractional percentage of potash. This fact, combined with observations of the refractive indices, leads to the conclusion that the isotropic material is mainly analcite and not leucite.—Dr. G. F. H. Smith and Dr. G. T. Prior: On a Fluo-arsenate from the Indian manganese deposits. A crystallographical and chemical examination made of the green arsenate from Kajlidongri, Jhábua State, mentioned in Mr. Fermor's monograph on the manganese-ore deposits of India (Rec. Geol. Surv. India, 1908), led to the following results:—Composition $(Mg\,F)\,Ca\,As\,O_4$. Specific gravity, 3·768. Hardness, 3$\frac{1}{2}$. Colour, apple- to brownish-green. Monoclinic: $a : b : c = 0{\cdot}7485 : 1 : 0{\cdot}8453$: $\beta = 120° 50'$. Forms present (010), (110), (111), ($\bar{1}31$), (311), ($\bar{1}12$), ($\bar{1}52$). Good cleavage parallel to ($\bar{1}01$), and partings parallel to (110), ($\bar{1}02$), (331). Twin plane (100). Refractive indices, 1·640, 1·660, 1·666. Acute bisectrix nearly perpendicular to ($\bar{1}01$), and axial plane at right angles to the plane of symmetry, but no horizontal dispersion was noticed; $2E = 105°$ approximately, with negative birefringence. The mineral is probably identical with tilasite, which was first described by Sjögren in 1905, from the manganese deposits of Långban, Sweden.—Mr. H. E. Clarke and Professor H. L. Bowman:

On the composition of a stone from the meteoric shower which fell at Dokáchi, Bengal, on October 22, 1903. The small crusted stone examined, weighing 17·8 grams, shows chondritic structure, and belongs to the class Ci of Tschermak. The chief constituent minerals are bronzite (37·9 per cent.), olivine (37·7 per cent.), nickel-iron (18·5 per cent.), troilite (4·1 per cent.).—Dr. G. F. H. Smith exhibited cut and rough specimens of synthetical sapphire, recently produced by Professor Verneuil, oxides of iron and titanium being the colouring agents.

CORRESPONDENCE.

THE USE OF THE TERM 'LATERITE'.

Sir,—I have read Mr. T. Crook's letter in the November number of this journal with interest, but fail to see that he has made it easier for everyone to agree with him in his use of the term 'laterite'. I do not say that the engineers of the Malay Peninsula are correct in their use of the term. They have not adhered to Buchanan's definition, but have extended it to cover masses of ironstone, which, even had they occurred in decomposition products of crystalline rocks, I am quite ready to admit would not have been included in the term 'laterite' by the originator. Similarly, I admit that in other countries the original definition has been abandoned, which is perhaps deplorable; but the question that occurred to me immediately on reading Mr. Crook's remarks was, what reason has he to consider himself in a better position as regards the original definition, which is conveniently given in his letter, than the rest?

The essential point in Buchanan's definition is the fact that laterite 'sets' when exposed to the atmosphere, and can be used as brick. Buchanan also says that it contains a very large quantity of iron in the form of red and yellow ochres. Now Mr. Crook says that Buchanan attached to the term 'laterite' a significance that is in strict agreement with modern usage, by which we must understand Mr. Crook's insistence on the importance of the free aluminium hydroxides. I can only take this to mean that in Mr. Crook's opinion the 'setting' of laterite is essentially due to the dehydration of the aluminium hydroxides, and if Mr. Crook can prove this proposition I am prepared to accept his definition as a somewhat obscure paraphrase of Buchanan's definition. At present I am unable to accept it as a paraphrase because, although a change from gibbsite to the hard but very brittle diaspore may to a small extent account for the hardening, it is but reasonable to suppose that in the case of Buchanan's indurated clays containing "a very large quantity of iron", the redistribution and partial dehydration of the ferric hydrate are the factors that make laterite commercially valuable (vide *Manual of the Geology of India*, p. 379, and Sir Thomas H. Holland's paper in the 1903 volume of the Geol. Mag., pp. 65, 66, and 69).

It is clear that the original definition of laterite has been generally ignored, perhaps because it appealed to an economic rather than a scientific point of view. But with that idea of economic value

there was in the earlier writings always more than a suggestion of an abundance of iron, and those who apply the term now to distinctly ferruginous weathering products may be no nearer heresy than those who, following up the work of Max Bauer and Dr. Warth, insist on the presence of free aluminium hydroxides as the test of laterite. To me the term seems to be now of little value, and unless we can agree to apply it only to such materials as were described by Buchanan as possessing qualities that make them workable as a substitute for brick, I do not see why it should be retained. Mr. Crook tells me that I am not justified from a scientific standpoint in suggesting that highly aluminous laterite should be called bauxite. I follow Mr. Crook's argument, but since the following phrases occur in the papers by Sir Thomas Holland and Dr. Warth & F. J. Warth published in the Geological Magazine for 1903—"laterite . . . agrees in essential characters with bauxite"—"the essential chemical similarity between bauxite and laterite"—"laterites in situ which are bauxites"—"these bauxites in blocks and in powder"—"laterite is bauxite in various degrees of purity"—I feel that I am justified in advocating simplicity of diction as opposed to the redefining of a term the utility of which to geologists is doubtful.

The engineers, even if they have misapplied the term, are now the chief users of it, and weight of numbers will compensate such lack of scientific accuracy as exists in the eyes of the world at large. In local publications geologists placed like myself must make use of the term in order that local readers may know what is being discussed, and it was the objection in the Imperial Institute Bulletin to such a local use of the term that led me to write in the first instance, since I foresaw that the same might happen to me also. I believe that all geologists are agreed in aiming at simplicity of terminology. Can any geologist who has kept abreast of the literature use the term 'laterite' now without feeling an obligation to explain what he means by it? And is it not simpler to say directly what we mean without using a term whose original significance we have discarded?

J. B. Scrivenor.

Geological Department, Batu Gajah,
Federated Malay States.
January 19, 1910.

CAPE GEOLOGY.

Sir,—Will you allow me to point out that your reviewer has made a mistake in his otherwise very kind remarks on the book on Cape Geology written by Mr. Du Toit and myself? He says that "no references are given to any of the authorities quoted": a glance through the book will show that references to a considerable number of publications, in fact whenever such a course seemed desirable, are given in the foot-notes. In a book of this sort the omission of references would be a very serious fault, so the oversight on the part of the reviewer should be corrected.

Arthur W. Rogers.

Fraserburg, Cape Colony.
January 1, 1910.

JAW APPARATUS OF *DISCOIDEA*.

SIR,—In the course of examining and arranging some specimens of foreign *Echinoidea*, formerly in the Wright Collection and recently purchased for the British Museum, I have found an internal cast in flint of a *Discoidea*, which, from its size and general contour, seems referable to *D. cylindrica* (Lam.), although it is a remarkably depressed form. This cast exhibits clear impressions of the dental apparatus in a fragmentary condition, at least three of the teeth being represented among the other portions of the jaws. The characters of the jaws in this specimen accord, so far as they are visible, with those of the individual in the Manchester Museum (GEOL. MAG., 1909, pp. 148–52), which is almost equally depressed in outline. In view of the extreme rarity of the preservation of the dental apparatus in this genus, the existence of an example in the National Collection seems worth a published record. Unfortunately the precise locality and horizon are unknown. The specimen is registered E. 10166.

HERBERT L. HAWKINS.

UNIVERSITY COLLEGE, READING.
February 17, 1910.

OBITUARY.

THE REV. GEORGE FERRIS WHIDBORNE, M.A., F.G.S., ETC.

BORN 1846. DIED FEBRUARY 14, 1910.

IT is with deep regret we learn, from the *Morning Post*, February 17, of the death of our valued friend the Rev. G. F. Whidborne, M.A., at Hammerwood, East Grinstead, from an attack of pneumonia, in his sixty-fourth year. Mr. Whidborne formerly resided at Torquay, and in later years at Westbury-on-Trym, near Bristol. For the past twenty-five years he had devoted himself to figuring and describing "the Devonian fauna of the South of England", in the annual volumes of the Palæontographical Society, the first part of which monograph appeared in vol. xlii for 1888, and of which eleven fasciculi had been issued, the last part being published in 1907. Mr. Whidborne had served for many years on the Council of the Palæontographical Society, and has contributed papers to the Quarterly Journal of the Geological Society (in 1881 and 1883) and numerous papers to the GEOLOGICAL MAGAZINE (1889–1901). He was a most generous and kind-hearted man, an excellent palæontologist, and greatly esteemed by a very large circle of friends and fellow-workers.

MISCELLANEOUS.

MR. JAMES REEVE, F.G.S., AND THE NORWICH CASTLE MUSEUM.

The admirable Museum originally known as the "Norfolk and Norwich Museum" was initiated in February, 1825, by a small body of private gentlemen, naturalists and antiquaries connected with the

city and county, and started with the modest annual subscription of 5*s.* each member. It is to the honour of these gentlemen and their friends and successors that the Norfolk and Norwich Museum continued (supported by voluntary contributions) for nearly seventy years, and had, at the time of its transfer to the Corporation, some fifteen years ago, in addition to its books and pictures, its antiquities, its recent and fossil collections, a fine series of British and foreign birds, and the finest collection of raptorial birds in the world, formed and presented to the Norfolk and Norwich Museum by the late John Henry Gurney, Esq.

In the Geological Collection are preserved the grand series of mammalian remains from the Forest Bed deposits of the Norfolk coast, formed by the late Mr. John Gunn, F.G.S., the Chalk and Crag collections of the late Mr. Samuel Woodward, besides those presented to the Museum in recent years by Mr. James Reeves, the present indefatigable curator.

In 1886 the Norwich Town Council, presided over by their then Mayor, Mr. John Gurney, proposed the conversion of the 'keep' and prison buildings adjoining the Norwich Castle into a series of museum galleries, with a view to the transfer of the collections now belonging to the Norfolk and Norwich Museum. A committee was formed to raise the necessary funds, to which Mr. John Gurney contributed the handsome sum of £5000.

More than £15,000 in addition were raised to complete the buildings, which were designed and carried out for the Corporation and the Museum Committee in 1887 and following years by Mr. E. Boardman, F.R.I.B.A., the city architect. Some years later Mr. James Reeve, F.G.S., the Curator, who had devoted forty-six years of his life to the Norfolk and Norwich Museum, undertook and carried out the transfer of the entire collections from the old building in St. Andrew's Street to the grand series of eight new spacious galleries and the 'keep' of the old feudal castle, and has since devoted sixteen years to the no less arduous task of arranging for exhibition the vast array of objects of art, pictures, antiquities, and relics; also of minerals, geological specimens, skeletons and skins of mammals, of birds and their eggs, of reptiles, of corals, insects, and mollusca, which now adorn these spacious and well-appointed galleries.

But life is short and art is long—what wonder, then, that Mr. James Reeve, who has served the Norfolk and Norwich Museum, and subsequently the Corporation of Norwich, for an almost unexampled period of sixty-two years, should be wishful to retire from his arduous duties and obtain some needful repose! Even now his beloved Museum is his first consideration, and he writes to the Town Clerk: "I have naturally no desire to entirely relinquish a connexion which has lasted for more than half a century." Whereupon the Castle Museum Committee (on January 5, 1910) resolved to place on record its high appreciation of the long and eminent services rendered by Mr. James Reeve, F.G.S., the Curator of the Castle Museum, etc., and to recommend that, in order to retain his valuable knowledge and experience, he be appointed Consulting Curator of the Museum, and that he be relieved from obligation to attend at the Castle during

the usual hours that the Museum is open, but continue to give his advice and assistance to the Committee and its officers when required. It was further resolved that the salary of Mr. Frank Leney,[1] Assistant Curator, be raised to £200 per annum from January 1, 1910, and that the consideration of the appointment of a Curator to fill the position to be vacated by Mr. James Reeve be deferred until after June 24, 1910.

At a subsequent meeting on February 15 Dr. E. E. Blyth, the newly-constituted[2] Right Honourable the Lord Mayor, with the Aldermen and Councillors, adopted the report of the Museum Committee, and passed a cordial and well-deserved eulogium on Mr. James Reeve for his long and valuable services to the City of Norwich and its Museum. The Lord Mayor added that it was mainly due to Mr. Reeve that the Castle Museum contained more gems and less rubbish than any other of the Municipal Galleries in England. We heartily rejoice at the recognition given by the Corporation of Norwich to Mr. James Reeve for his valuable services, and trust that his life may long be spared to enjoy his comparative leisure and the well-earned appreciation of his fellow-citizens in Norwich.

In Memory of Dr. Slimon, of Lesmahagow, Lanarkshire.

So long ago as 1855, at the Meeting of the British Association, Mr. Robert Slimon exhibited in Glasgow a remarkable series of fossils from Lesmahagow. Among these was a series of Crustacean remains, with curious scale-like markings, exposed upon the surface of dark-coloured schist or flags, to which Mr. David Page called Sir Roderick Murchison's attention. Murchison at once recognized them as the remains of *Pterygotus*, and from the nature of the matrix concluded they belonged to the uppermost Silurian zone. At the close of the meeting, accompanied by Sir Andrew Ramsay and Dr. Slimon, Murchison visited the district, and, as the result of that visit, a very important addition was made to Scottish geology. Shortly afterwards Murchison read a paper to the Geological Society of London,[3] in which he stated that the dark fossiliferous shales exposed in the Logan Water pass conformably upwards into the Old Red Sandstone of that district. His paper was illustrated by a horizontal section showing the relationship that existed between the Upper Silurian strata of that region and the Old Red Sandstone. In his paper he also pointed out that Dr. Slimon's collection contained sculptured plates of Crustaceans exactly similar to those which had already been referred to *Pterygotus*. Associated with these he had found specimens of *Lingula cornea* and *Trochus helicites* shells, which were characteristic of the Upper Silurian rocks of Wales. Such, then, is a brief account of this remarkable discovery in Scottish geology made by Dr. Slimon sixty years ago.

The earliest Crustacean fossils, collected so zealously by Mr. Slimon,

[1] Formerly of the British Museum (Natural History), Cromwell Road, S.W.

[2] By command of His Majesty the King, February 2, 1910, that "the Chief Magistrate of the capital of the 'King's county' (Norfolk) should be raised to the rank of Lord Mayor" (*Eastern Daily Press*, February 16, 1910).

[3] See Q.J.G.S., 1856, vol. xii, pp. 15–19.